COSEWIC
Assessment and Status Report

on the

Proud Globelet
Patera pennsylvanica

in Canada

ENDANGERED
2015

COSEWIC
Committee on the Status
of Endangered Wildlife
in Canada

COSEPAC
Comité sur la situation
des espèces en péril
au Canada

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Proud Globelet — Robert Forsyth (Black Oak Heritage Forest, April 19 1996, collector: Michael J. Oldham, CMNML 096170).

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COSEWIC
Assessment Summary

Assessment Summary – May 2015

Common name
Proud Globelet

Scientific name
Patera pennsylvanica

Status
Endangered

Reason for designation
This large terrestrial snail is found in the upper mid-west of North America, with Canada's single recorded occurrence in and near a wooded park in Windsor, Ontario. General snail surveys conducted throughout southern Ontario over the last century have not detected this species anywhere else. Freshly dead shells were found in 1992 and 1996 but only dead, weathered shells were found in extensive surveys in 2013. Human intrusions and disturbances from recreational activities and ecosystem modifications from invasive plants and animals, the surrounding urbanization, pollution from local and regional sources, and climate change may have contributed to the species' demise; it appears another native snail disappeared from the same area at the same time.

Occurrence
Ontario

Status history
Designated Endangered in May 2015.

COSEWIC
Executive Summary

Proud Globelet
Patera pennsylvanica

Wildlife Species Description and Significance

Proud Globelet, *Patera pennsylvanica* is a terrestrial snail in the family Polygyridae. The yellowish, round shell (15-20 mm diameter) lacks a tooth-like protuberance at the shell opening compared to other species of the genus. The sole known Canadian population occurred in and near the Black Oak Heritage Forest owned by the City of Windsor. Although the ecological significance of Proud Globelet is unknown, gastropods, in general, play important roles in forest ecosystem functioning via nutrient cycling and soil building processes.

Distribution

Proud Globelet is found from southwestern Ontario south to Iowa and Missouri and east to Pennsylvania. The species' entire range, nearly all of which is in the U.S., is about 534,453 km^2. Canada has less than 0.001% of the global range. Empty, fresh shells were found in 1992 and 1996 in Windsor. Empty, weathered shells were found in 2013 in the same place and nearby. No live individual was ever recorded in Canada. This species was not found elsewhere in southwestern Ontario in gastropod surveys from 1916 to 2013.

Habitat

Proud Globelet generally occurs on wooded hillsides or in ravines. In Canada, the species has been reported in a sandy oak forest and a disturbed light industrial site. Food requirements for Proud Globelet might be fungi, leaf litter and fresh plant material, but some Polygyridae are carnivorous. In Ontario, trends observed in the habitat of Proud Globelet include a general reduction in oak forests and reduction in biodiversity, the latter potentially affecting the snail communities.

Biology

Very little is known about the biology of Proud Globelet. From other species in the polygyrid family, it has been inferred that mating occurs in fall or early spring and oviposition in spring to late summer. Clutch size ranges between 20 and 80 eggs that hatch about 20 to 60 days after oviposition. Growth rate and, consequently, adult size (reached after 1-2 years) are highly variable. Growth periods correspond to activity periods from spring to fall. Sexual maturity is reached after 2 to 3 years, and lifespan has been estimated to range between 3 and 5 years. Snails are ectotherms and prone to freezing in winter or dehydration in summer. Different strategies have evolved to enable the species to survive extreme temperatures and drought besides going into dormancy. Hibernation in the Polygyridae extends from early October until mid-April in temperate regions. Aestivation occurs occasionally during prolonged heat and drought periods. Snails rely on humidity-buffered refugia and snow cover for dormancy survival. Most Polygyridae are active at dusk or during the night with dispersal for colonization of new habitat being slow, around 35 m in 3 years. Predation and parasites can be a source of mortality for land snails.

Population Sizes and Trends

Seventeen person-hours of search effort in different light and weather conditions were spent trying to find live individuals in a 200 m x 100 m square plot in the Black Oak Heritage Forest and in a nearby former light industrial area in 2013. The plot encompasses the area where the snail had been previously found. Fourteen empty shells (estimated to be 5-15 years old) were found under leaf litter in the upper 5 cm of the soil in addition to other snail and slug species in the forest plot; Proud Globelet was not found elsewhere in the forest but one shell also was found south of the forest in the nearby former light industrial area. The complete absence of live individuals and the age of the shells found in 2013 suggest that the population has substantially declined since 1996; there is a strong likelihood that Proud Globelet has disappeared from this area and from Canada as it has only ever been found in this area in southwestern Ontario. Rescue from the U.S. population is unlikely because the Detroit and St. Clair rivers and Lake Erie are dispersal barriers.

Threats and Limiting Factors

Human impacts such as pollution, garbage accumulation, intensive recreational use and changes to soil composition and hydrology can affect the snail population. Introduced species, such as plants, earthworms and other gastropods can affect native snail populations through alteration of the soil nutrient cycle, reduction of leaf litter and inter-specific competition. The introduced slug Dusky Arion, *Arion subfuscus*, was abundant at the site where Proud Globelet shells were found and was observed feeding on fungi. Climate change can have a large impact on snail survival. In temperate regions, climate change will involve increases in both average temperature and the frequency of extreme weather events such as heat waves, drought, and high precipitation, as well as an absence of insulating snow cover. Snails are limited by their low dispersal or escape capacity, relatively long generation time, low physiological resistance to fluctuating environmental factors, susceptibility to bioaccumulation of toxic agents, and limited genetic flow.

Protection, Status, and Ranks

Global Rank: G4 (Apparently Secure), National Rank (Canada): N1 (Critically Imperilled), National Rank (US): N4 (Apparently Secure). Sub-national ranks are "critically imperilled" (S1) in Ontario and West Virginia, "critically imperilled" to "imperilled" (S1S2) in Pennsylvania. Michigan listed Proud Globelet as a species of special concern.

TECHNICAL SUMMARY

Patera pennsylvanica

Proud Globelet — Patère de Pennsylvanie

Range of occurrence in Canada (province/territory/ocean): Ontario

Demographic Information

Generation time (usually average age of parents in the population; indicate if another method of estimating generation time indicated in the IUCN guidelines(2011) is being used)	3-5 years (in Polygyridae)
Is there an [observed, inferred, or projected] continuing decline in number of mature individuals?	N/A (no live individuals)
Estimated percent of continuing decline in total number of mature individuals within [5 years or 2 generations]	N/A (no live individuals)
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over the last [10 years, or 3 generations].	Unknown but could be close to 100% Fresh dead shells observed in 1992 and 1996 but only old weathered shells (5-15 years old) observed in 2013.
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 years, or 3 generations].	N/A (no live individuals)
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over any [10 years, or 3 generations] period, over a time period including both the past and the future.	Unknown but could be close to 100% Fresh dead shells observed in 1992 and 1996 but only old weathered shells (5-15 years old) observed in 2013.
Are the causes of the decline a. clearly reversible and b. understood and c. ceased?	a. No b. No c. No
Are there extreme fluctuations in number of mature individuals?	N/A (no live individuals)

Extent and Occupancy Information

Estimated extent of occurrence	4 km²
Index of area of occupancy (IAO) (Always report 2x2 grid value).	4 km²
Is the population "severely fragmented" i.e., >50% of its total area of occupancy is in habitat patches that are (a) smaller than would be required to support a viable population, and (b) separated from other habitat patches by a distance larger than the species can be expected to disperse?	a. No b. No

Number of "locations"* (use plausible range to reflect uncertainty if appropriate)	1-2
Is there an [observed, inferred, or projected] decline in extent of occurrence?	N/A (no live individuals)
Is there an [observed, inferred, or projected] decline in index of area of occupancy?	N/A (no live individuals)
Is there an [observed, inferred, or projected] decline in number of subpopulations?	N/A (no live individuals)
Is there an [observed, inferred, or projected] decline in number of "locations"*?	N/A (no live individuals)
Is there an [observed, inferred, or projected] decline in [area, extent and/or quality] of habitat?	Yes, inferred, quality
Are there extreme fluctuations in number of subpopulations?	N/A (no live individuals)
Are there extreme fluctuations in number of "locations"*?	N/A (no live individuals)
Are there extreme fluctuations in extent of occurrence?	N/A (no live individuals)
Are there extreme fluctuations in index of area of occupancy?	N/A (no live individuals)

Number of Mature Individuals (in each subpopulation)

Black Oak Heritage Forest, City of Windsor	0 Mature Individuals Alive (15 shells of adults and juveniles)
Total	0

Quantitative Analysis

Probability of extinction in the wild is at least [20% within 20 years or 5 generations, or 10% within 100 years].	N/A (no live individuals)

Threats (from highest impact to least, as per IUCN Threats Calculator)

Was a threats calculator completed for this species: No (no live individuals)

i. Human intrusions and disturbances
ii. Natural system modifications
iii. Pollution
iv. Climate change and extreme weather

What additional limiting factors are relevant?
Low dispersal or escape capacity, relatively long generation time, low physiological resistance to fluctuating environmental factors, susceptibility to bioaccumulation of toxic agents, and limited genetic flow.

* See Definitions and Abbreviations on COSEWIC website and IUCN (Feb 2014) for more information on this term.

Rescue Effect (immigration from outside Canada)

Status of outside population(s) most likely to provide immigrants to Canada.	Michigan: SNR (by NatureServe but Special Concern in Michigan publication) Ohio: SNR Pennsylvania:S1S2 New York: not present
Is immigration known or possible?	Yes
Would immigrants be adapted to survive in Canada?	Unknown
Is there sufficient habitat for immigrants in Canada?	Unknown
Are conditions deteriorating in Canada?[+]	Yes
Are conditions for the source population deteriorating?[+]	Unknown
Is the Canadian population considered to be a sink?[+]	N/A
Is rescue from outside populations likely?	No

Data Sensitive Species

Is this a data sensitive species? No

Status History

COSEWIC: Designated Endangered in May 2015.

Status and Reasons for Designation:

Status:	**Alpha-numeric codes:**
Endangered	B1ab(iii)+2ab(iii); D1
Reasons for designation: This large terrestrial snail is found in the upper mid-west of North America, with Canada's single recorded occurrence in and near a wooded park in Windsor, Ontario. General snail surveys conducted throughout southern Ontario over the last century have not detected this species anywhere else. Freshly dead shells were found in 1992 and 1996 but only dead, weathered shells were found in extensive surveys in 2013. Human intrusions and disturbances from recreational activities and ecosystem modifications from invasive plants and animals, the surrounding urbanization, pollution from local and regional sources, and climate change may have contributed to the species' demise; it appears another native snail disappeared from the same area at the same time.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Not applicable. No live individuals have ever been observed in Canada.
Criterion B (Small Distribution Range and Decline or Fluctuation): Meets Endangered B1ab(iii)+2ab(iii) because both the EOO (4 km^2) and IAO (4 km^2) are well below the thresholds for Endangered (<5,000 km^2 and <500 km^2, respectively), the species is found in fewer than 5 locations, and there is a projected continuing decline in (iii) area, extent, and quality of habitat.

[+] See Table 3 (Guidelines for modifying status assessment based on rescue effect).

Criterion C (Small and Declining Number of Mature Individuals): Not applicable. Endangered C2 is not applicable because no live individuals have ever been observed in Canada.
Criterion D (Very Small or Restricted Population): Meets Endangered D1 as population estimated to contain fewer than 250 mature individuals although no live individuals have ever been observed in Canada. Threatened D2 also is applicable as there are fewer than 5 locations, the IAO is < 20 km^2 and the species is prone to the effects of human activities or stochastic events that could result in it becoming extinct, extirpated or critically endangered within 1 or 2 generations.
Criterion E (Quantitative Analysis): Not applicable as analyses have not been done.

COSEWIC HISTORY

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) was created in 1977 as a result of a recommendation at the Federal-Provincial Wildlife Conference held in 1976. It arose from the need for a single, official, scientifically sound, national listing of wildlife species at risk. In 1978, COSEWIC designated its first species and produced its first list of Canadian species at risk. Species designated at meetings of the full committee are added to the list. On June 5, 2003, the *Species at Risk Act* (SARA) was proclaimed. SARA establishes COSEWIC as an advisory body ensuring that species will continue to be assessed under a rigorous and independent scientific process.

COSEWIC MANDATE

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assesses the national status of wild species, subspecies, varieties, or other designatable units that are considered to be at risk in Canada. Designations are made on native species for the following taxonomic groups: mammals, birds, reptiles, amphibians, fishes, arthropods, molluscs, vascular plants, mosses, and lichens.

COSEWIC MEMBERSHIP

COSEWIC comprises members from each provincial and territorial government wildlife agency, four federal entities (Canadian Wildlife Service, Parks Canada Agency, Department of Fisheries and Oceans, and the Federal Biodiversity Information Partnership, chaired by the Canadian Museum of Nature), three non-government science members and the co-chairs of the species specialist subcommittees and the Aboriginal Traditional Knowledge subcommittee. The Committee meets to consider status reports on candidate species.

DEFINITIONS
(2015)

Wildlife Species	A species, subspecies, variety, or geographically or genetically distinct population of animal, plant or other organism, other than a bacterium or virus, that is wild by nature and is either native to Canada or has extended its range into Canada without human intervention and has been present in Canada for at least 50 years.
Extinct (X)	A wildlife species that no longer exists.
Extirpated (XT)	A wildlife species no longer existing in the wild in Canada, but occurring elsewhere.
Endangered (E)	A wildlife species facing imminent extirpation or extinction.
Threatened (T)	A wildlife species likely to become endangered if limiting factors are not reversed.
Special Concern (SC)*	A wildlife species that may become a threatened or an endangered species because of a combination of biological characteristics and identified threats.
Not at Risk (NAR)**	A wildlife species that has been evaluated and found to be not at risk of extinction given the current circumstances.
Data Deficient (DD)***	A category that applies when the available information is insufficient (a) to resolve a species' eligibility for assessment or (b) to permit an assessment of the species' risk of extinction.

* Formerly described as "Vulnerable" from 1990 to 1999, or "Rare" prior to 1990.

** Formerly described as "Not In Any Category", or "No Designation Required."

*** Formerly described as "Indeterminate" from 1994 to 1999 or "ISIBD" (insufficient scientific information on which to base a designation) prior to 1994. Definition of the (DD) category revised in 2006.

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The Canadian Wildlife Service, Environment Canada, provides full administrative and financial support to the COSEWIC Secretariat.

COSEWIC Status Report

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Proud Globelet

Patera pennsylvanica

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2015

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Table 1. Summary of sites surveyed in Ontario for Proud Globelet (*Patera pennsylvanica*) in 2013. All sites in Windsor are indicated in italics. Observers were Jane Bowles (JMB), Tammie Dobie (TD), Robert Foster (RFF), Allan Harris (AGH), Annegret Nicolai (AN), Michael Oldham (MJO), Mykola Merkulov (MM), Hiroko Udaka (HU), Litza Coello (LC). CA – Conservation Area, NCC – Nature Conservancy of Canada, TTLT – Thames Talbot Land Trust. Refer to Figure 3 for localities. Geographic coordinates have been removed. Contact the COSEWIC Secretariat for access. 7

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Appendix 1. Records of Proud Globelet (*Patera pennsylvanica*) in Canadian museums and private collections. CMN – Canadian Museum of Nature. CMNML – CMN accession number. ROM – Royal Ontario Museum. ROMCN – ROM accession number. Geographic coordinates have been removed. Contact the COSEWIC Secretariat for access. 35

Appendix 2. Terrestrial gastropods found during the search for Proud Globelet (*Patera pennsylvanica*) in and near the Black Oak Heritage Forest, Windsor, Essex County, in 2013. Observers were Annegret Nicolai (AN), Michael Oldham (MJO), Jane Bowles (JMB) and Mykola Merkulov (MM).* denotes introduced exotic species. 36

Appendix 3. Museum records of Proud Globelet, *Patera pennsylvanica*, in the Global Biodiversity Information Facility (GBIF) database. FLMNH - Florida Museum of Natural History, MCZ - Museum of Comparative Zoology at Harvard University, LI - Biologiezentrum Linz Oberösterreich, NMNH - National Museum of Natural History, Smithsonian Institution, ANSP - Academy of Natural Sciences Philadelphia, NMR - Natural History Museum Rotterdam, FMNH - Field Museum of Natural History, NTSRV - NatureServe Central Databases, MACN - Museo Argentino de Ciencias Naturales. Geographic coordinates have been removed. Contact the COSEWIC Secretariat for access..... 37

WILDLIFE SPECIES DESCRIPTION AND SIGNIFICANCE

Name and Classification

Kingdom: Animalia

Phylum: Mollusca

Class: Gastropoda

Order: Pulmonata

Suborder: Stylommatophora

Family: Polygyridae

Genus: *Patera*

Species: *Patera pennsylvanica* (Green 1827) – Proud Globelet

Proud Globelet has been recognized as a species since 1827. Although placed in various genera, including *Mesodon* and *Polygyra* (see Pilsbry 1940), the species is currently assigned to the genus *Patera* (Emberton 1991; Turgeon *et al.* 1998). Emberton's systematic revision assigned Proud Globelet to the subgenus *Ragdaleorbis*, and it is the sole species in this subgenus within *Patera*.

There are 13 species in the genus *Patera*, two of which inhabit the eastern United States and Canada (Grimm *et al.* 2010). Besides Proud Globelet, one apparently introduced population of Flat Bladetooth, *Patera appressa*, has been recorded in Ontario (Grimm *et al.* 2010).

Morphological Description

A general characteristic of this genus is the imperforate umbilicus (hole at the central part of the underside of the shell) (Pilsbry 1940). Morphologically, Proud Globelet is unlike any other species of *Patera*, which accounts for its placement in the subgenus *Ragsdaleorbis*. Proud Globelet (Figure 1) lacks a parietal tooth-like protuberance on the aperture wall, has a higher spire (conical point at top of the shell) and the last whorl is more markedly descending at the aperture (Grimm *et al.* 2010). Shells are thin, regularly striate, yellowish olive with 5¾ to 6 whorls in adults. The lip of the aperture is white and narrowly reflected with a low prominence on the inner rim of the baso-columellar margin. Adult shells measure between 10 and 15 mm high and between 15 and 20 mm in diameter.

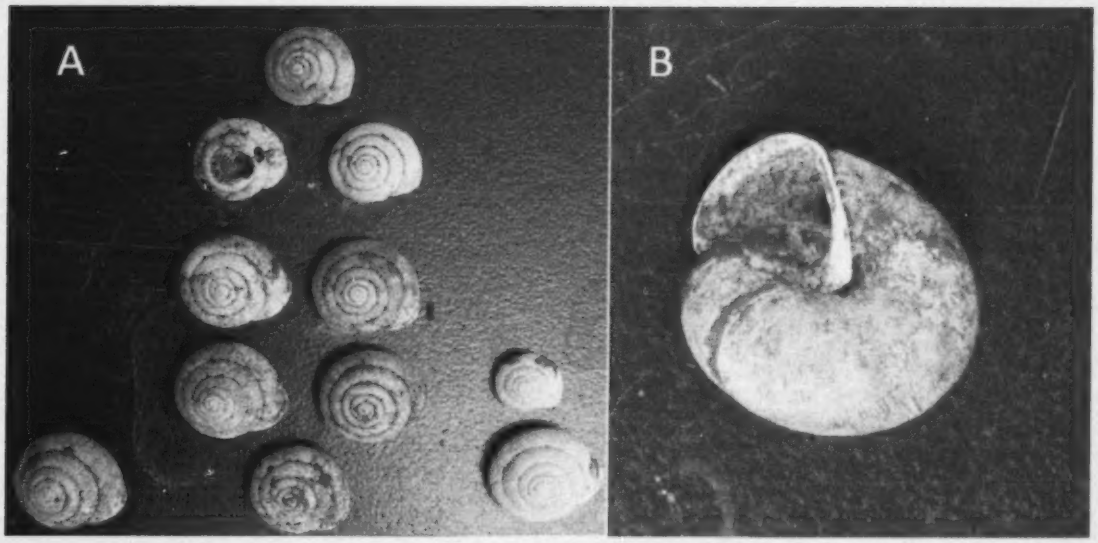

Figure 1. A) Best conserved shells of Proud Globelet (*Patera pennsylvanica*) found in the south part of the Black Oak Heritage Forest in the City of Windsor, Essex County, during the survey of summer 2013. B) Shell found in the soil with partial periostracum. (Photo credit: Annegret Nicolai.)

Population Spatial Structure and Variability

Canada's only known population of Proud Globelet is/was located in and near the Black Oak Heritage Forest, City of Windsor, Essex County, Ontario (Table 1; Appendix 1 and 2; Grimm 1996; NatureServe 2013). No genetic or population structure data are available. No other populations are known to exist in Canada and dispersal between potential sites has been greatly reduced with anthropogenic changes to the landscape. Less than 5% of the Essex Region is forested (ERCA 2002). Most patches of remaining forest are less than 10 ha. Habitat is highly fragmented with many possible barriers to forest snail dispersal, such as roads, agricultural fields and urban areas. When migration is limited between low-density populations there might be a high degree of genetic structuring due to reduced gene flow as observed in other Polygyridae (Anderson 2007).

Table 1. Summary of sites surveyed in Ontario for Proud Globelet (*Patera pennsylvanica*) in 2013. All sites in Windsor are indicated in italics. Observers were Jane Bowles (JMB), Tammie Dobie (TD), Robert Foster (RFF), Allan Harris (AGH), Annegret Nicolai (AN), Michael Oldham (MJO), Mykola Merkulov (MM), Hiroko Udaka (HU), Litza Coello (LC). CA – Conservation Area, NCC – Nature Conservancy of Canada, TTLT – Thames Talbot Land Trust. Refer to Figure 3 for localities. Geographic coordinates have been removed. Contact the COSEWIC Secretariat for access.

Site	Site Name	Effort (person-hours)	Observers	Date(s)	*Patera pennsylvanica*?	Weather
1	*Black Oak Heritage Forest, south part, Windsor*	*14*	*AN, JMB, MJO*	*May 3, July 28, Aug 27-28, Sep 5*	***Shells***	*20°C, sunny 20-23°C, humid or rainy*
2	*Former light industrial area south of Black Oak Heritage Forest, Windsor*	*3*	*MJO*	*Sep 5*	***Shell***	22°C, sunny
3	*Black Oak Heritage Forest, north part, Windsor*	*4*	*AN, MJO,*	*Apr 29*	*No*	*18°C, overcast*
4	*Devonwood Conservation Area, Windsor*	*2*	*AN, MJO*	*April 29*	*No*	*18°C, overcast*
5	*Springgarden Road Park, Windsor*	*2*	*AN, MJO*	*April 29*	*No*	*18°C, overcast*
6	*Ojibway Park, Windsor*	*5*	*AN, MJO, JMB*	*Apr 29, May 3*	*No*	*18°C, overcast; 20°C, sunny*
7	*Malden Park, Windsor*	*2*	*AN, JMB*	*May 3*	*No*	*20°C, sunny*
8	*Oakwood, Windsor*	*2*	*AN, MM*	*Aug 27*	*No*	*22°C, sunny, humid*
9	*Brunet Park, La Salle*	*1*	*AN*	*Aug 28*	*No*	*22°C, sunny, humid*
10	*South Cameron Woodlot, Windsor*	*1*	*AN, MM*	*Aug 28*	*No*	*22°C, sunny, humid*
11	*Peche Island, Windsor*	*2*	*AN, HU*	*May 19*	*No*	*22°C, sunny*
12	Middle Island, Point Pelee National Park, Lake Erie	6; 12	RFF, AN, MJO; AN, TD, MM	May 1; Aug 29	No	18°C, sunny; 23°C, sunny, humid
13	East Sister Island Provincial Park, Lake Erie	4.5	TD, RFF, AGH, AN, MJO	Apr 30	No	18°C, sunny
14	Middle Sister Island, Lake Erie	3.5	TD, RFF, AGH, AN, MJO	Apr 30	No	18°C, sunny
15	Lighthouse Point Provincial Nature Reserve, Pelee Island	1.5; 2	RFF, AN, MJO; AN, MM	May 1; Aug 25	No	20°C, sunny, dry, windy; 25°C, sunny, humid
16	Erie Sand and Gravel NCC parcel, Pelee Island	3.5	AN, MJO, AGH	May 2	No	24°C, sunny, dry
17	Middle Point Woods – north part, NCC, Pelee Island	2; 1	AGH, RFF, MJO, AN; AN	May 2; Aug 25	No	24°C, sunny, dry; 24°C, sunny, humid
18	Gibwood Property, NCC, Pelee Island	2	AN, MJO	May 2	No	22°C, sunny, dry
19	Richard and Beryl Ivey Nature Reserve, NCC, Pelee Island	1.5	RFF, AGH, AN	May 1	No	24°C, sunny

Site	Site Name	Effort (person-hours)	Observers	Date(s)	*Patera pennsylvanica*?	Weather
20	Winery property, Pelee Island	4	RFF, AGH, AN, MJO	May 2	No	24°C, sunny
21	Porchuk Property, NCC, Pelee Island	2	AN, MJO	May 2	No	22°C, sunny
22	Fish Point Provincial Nature Reserve, Pelee Island	5	RFF, AGH, AN	May 1	No	18°C, sunny
23	Fleck Property, Pelee Island	1	RFF	May 2	No	22°C, sunny
24	Essex Conservation Authority lands at Stone Road Alvar, Pelee Island	1	AGH	May 2	No	22°C, sunny
25	Ontario Nature Stone Road Alvar, Pelee Island	1; 2	AGH; AN, MM	May 2; Aug 27	No	22°C, sunny; 25°C, sunny,
26	Cohen Shaughnessy Property, NCC, Pelee Island	1; 2	AGH; AN,MM	May 2; Aug 27	No	23°C, sunny; 25°C, sunny, humid
27	Krestel Parcel, NCC, Pelee Island	1	AGH	May 1	No	20°C, sunny
28	Middle Point Woods – south part, NCC, Pelee Island	1.5; 1	RFF, AGH, AN; AN, MM	May 1, 2; Aug 26	No	22°C, sunny; 25°C, sunny, humid
29	Florian Diamante Nature Reserve, NCC, Pelee Island	4.5	AGH, RFF, AN	May 2	No	22°C, sunny
30	Point Pelee National Park, Tip	3	AGH, AN, MJO	Apr 28	No	15°C, rain, stopped later
31	Point Pelee National Park, tip to Visitor Centre	2	AGH, AN, MJO	Apr 28	No	15°C, rain, stopped later
32	Point Pelee National Park, West Beach Trail	3	AGH, AN, MJO	Apr 28	No	15°C, rain, stopped later
33	Point Pelee National Park, Dunes Picnic area	1	RFF	April 29	No	18°C, overcast
34	Point Pelee Nataional Park, east of Dunes Picnic area	1	AGH	April 29	No	18°C, overcast
35	Point Pelee National Park, Sanctuary Picnic area	1.5	AGH, MJO, AN	Apr 28	No	17°C, overcast
36	Oxley Swamp, NCC	2	AN, HU	May 20	No	26°C, sunny, humid
37	Cedar Creek CA	3	RFF, AGH	April 29	No	12°C, overcast
38	Kopegaron Woods CA	4	RFF, AGH, AN, MJO	Apr 29, 30	No	14°C, overcast
39	Two Creeks CA	2	MJO	May 18	No	-
40	Canard River CA	2	AN, MJO	April 29	No	18°C, overcast
41	Maidstone CA	2	RFF, AGH	April 29	No	14°C, overcast
42	Rondeau Provincial Park	3; 3.5	MJO, JMB; AGH	May 17; Sep 4	No	22°C, sunny
43	Sinclair's Bush	2	MJO, JMB	May 17	No	-
44	Thames Grove CA	1	AN, JMB	May 3	No	20°C, sunny
45	Moraviantown First Nation	6	AN, JMB	June 7	No	15°C, overcast, humid

Site	Site Name	Effort (person-hours)	Observers	Date(s)	*Patera pennsylvanica*?	Weather
46	John E. Pearce Provincial Park	2	MJO	May 15	No	-
47	Newport Forest, TTLT	1; 2	AN; AN, HU	April 21; Sep 01	No	18°C, sunny, humid; 23°C after rain
48	Wardsville Woods TTLT	1	JMB	May 17	No	-
49	Backus Woods, NCC	1; 3	MJO; AGH	May 15; Sep 2	No	18°C, sunny
50	St. Williams Conservation Reserve	2	MJO	May 15	No	-
51	Calton Swamp	1	MJO	May 15	No	-
52	Lake Whittaker CA	2	AN,HU	June 8	No	18°C, overcast
53	Westminster Ponds, London	1	AN	April 7	No	15°C, overcast
54	Komoka Provincial Park	1	AN, HU	Jan 13	No	12°C, humid, no snow
55	Western University, London	0.5	AN	April 15	No	18°C, sunny
56	Canatara Park, Sarnia	3	JMB, MJO; AGH; AN, LC	May 16, August 3; Sep 22	No	22°C, sunny (Aug 3)
57	Killaly Meadows, London	1	AN	May 4	No	20°C, sunny
58	Lambton United Church Camp	2	AGH	August 3	No	25°C, sunny
59	Highland Glen CA	1	AGH	August 3	No	25°C, sunny
60	Joany's Woods TTLT	1	AN, JMB	April 1	No	12°C, overcast
61	Port Franks	2	AGH	August 4	No	24°C, sunny
62	Pinery Provincial Park	1;1	AN	May 5; July 07	No	20°C, sunny; 25°C, sunny
63	C.M. Wilson CA	2	MJO, JMB	May 16	No	-
64	Paxton Wood, Chatham	2	MJO, JMB	May 16	No	-
65	Skunk's Misery	2	MJO, JMB	May 16	No	-
66	Avon trail near St. Mary's	1	AN	Jul 27	No	20°C, rain
67	Long Point Provincial Park	2	AGH	Sep 2	No	24°C, sunny
68	Bickford Oak CA	2	AN, LC	Sep 22	No	18°C, cloudy, wet
69	Brigden Crown Game Reserve	2	AN, LC	Sep 22	No	18°C, cloudy, wet
70	Moore Wildlife Refuge CA	2	AN, LC	Sep 22	No	18°C, cloudy, wet
71	Perch Creek CA	2	AN, LC	Sep 21	No	20°C, cloudy, wet
72	Floodway CA	2	AN, LC	Sep 21	No	20°C, cloudy, wet
73	Petrolia CA	1	AN, LC	Sep 22	No	18°C, cloudy, wet

Site	Site Name	Effort (person-hours)	Observers	Date(s)	*Patera pennsylvanica*?	Weather
74	Rouge Park, Scarborough	4	AN	Sep 14, 15	No	22°C, sunny, humid
75	High Park, Grenadier Pond, Toronto	1	MM	Sep 22	No	18°C, cloudy, wet

Designatable Units

The sole Canadian population is/was within the COSEWIC Great Lakes Plains National Ecological Area (COSEWIC 2011). Genetic data and evidence of local adaptations are unavailable. Therefore, the Canadian occurrence is a single designatable unit.

Special Significance

The only known Canadian population of Proud Globelet occurs/occurred in the Carolinian Forest Region near the northern limit of the species' global range (Figure 2). This population may be genetically isolated from other populations in the United States and therefore has significance for conservation.

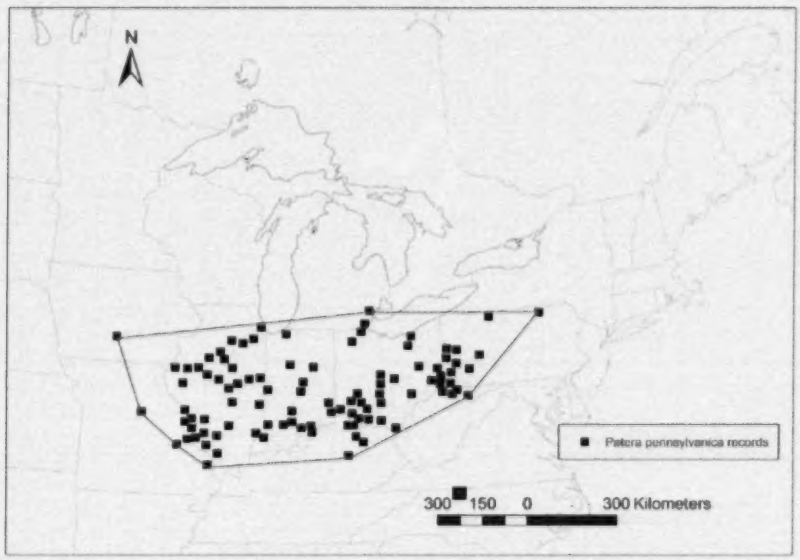

Figure 2. Global range of Proud Globelet, *Patera pennsylvanica*, based on Hubricht (1985) and updated with georeferenced data from Canadian museums (Appendix 1) as well as from the Global Biodiversity Information Facility (GBIF 2013) collected from different museums worldwide (Appendix 3). Data include records without date and with dates from 1882 to 2013. The global range was estimated using the minimum convex polygon method (534,453 km^2) by the report writers. All non-georeferenced data from GBIF, Canadian museums and Coppolino (2009) were verified to be within the range boundaries defined by the convex polygon.

The ecological significance of Proud Globelet is unknown. However, snails and slugs generally play important roles in forest ecosystem functioning, specifically by (i) aiding in decomposition, nutrient cycling and soil building processes (Mason 1970a,b; Jennings and Barkham 1979); (ii) providing food and essential nutrients to wildlife (South 1980; Churchfield 1984; Frest and Johannes 1995; Martin 2000; Nyffeler and Symondson 2001); and (iii) serving as hosts for parasitic worms (e.g., Rowley *et al.* 1987).

Proud Globelet is unknown to most Canadians. The Ojibway Nature Centre at Windsor published a species at risk list for the Ojibway Prairie Complex in Windsor and included the Proud Globelet (Pratt 2012).

It has no commercial value and is not an agricultural or garden pest.

Aboriginal traditional knowledge was not available for this species.

DISTRIBUTION

Global Range

Proud Globelet is/was distributed from southwestern Ontario south to Iowa and Missouri and east to Pennsylvania (Figure 2).

The global range covers 534,453 km^2 as measured by minimum convex polygon by the report writers (Figure 2).

Canadian Range

In Canada, the Proud Globelet is/was restricted to the Carolinian Forest region of Ontario, specifically to an area of 200 m x 100 m in the south part of the Black Oak Heritage Forest and to a less than approximately 100 m^2 site in a former light industrial area south of the Black Oak Heritage Forest in the City of Windsor (Figures 3 and 4, Grimm 1996). Empty, fresh shells of this species were first found in the Black Oak Heritage Forest in 1992 by Michael J. Oldham. Empty, fresh shells were found again in the same place in 1996 by M.J. Oldham, while only old, weathered shells were found in 2013 by A. Nicolai in the same place and by M.J. Oldham south of the Black Oak Heritage Forest on a former light industrial area (Table 1, Appendix 1 and 2). Fresh empty shells indicate recently dead individuals in 1992 and 1996 suggesting an extant population at that time. No living individuals of Proud Globelet have ever been documented in Canada.

Canada contains less than 0.001% of the global range of the species.

Extent of Occurrence and Area of Occupancy

The index of area of occupancy is 4 km^2 (i.e., species occurs/occurred in one 2 km x 2 km square).

The extent of occurrence of Proud Globelet in Canada is 4 km^2 (extent of occurrence equals index of area of occupancy).

Search Effort

Forsyth's (2013) references to Canadian occurrences of Proud Globelet were searched. Notable surveys include those conducted on the Lake Erie islands by Clapp (1916) and Goodrich (1916) and the efforts of John Oughton between about 1930 and 1940 (Oughton 1948). Grimm (1996) collected extensively in southern and eastern Ontario between 1970 and the mid-1990s, but his collection is only partially available. Collections at the Royal Ontario Museum, Canadian Museum of Nature and Bishops Mills Natural History Centre have been searched. None of these early general surveys was in the Black Oak Heritage Forest or Windsor area. Other worldwide collections were accessed via the Global Biodiversity Information Facility (GBIF 2013, Appendix 3).

Surveys between 1992 and 2012 also were general land snail searches by M.J. Oldham and A. Nicolai rather than targeted searches for Proud Globelet (Figure 3). From 1992-1996, 92 samples of about 25 species were recorded by M.J. Oldham, each sample containing several specimens of one species. He found fresh shells of recently dead Proud Globelet twice in the Black Oak Heritage Forest: in 1992 and 1996. In 2012 about 360 specimens of about 45 species were collected by A. Nicolai and sent to Robert Forsyth for curation but no Proud Globelet was found.

In 2013, 74 sites in southwestern Ontario were surveyed with a total effort of 233 person-hours to provide information for the preparation of status reports for Proud Globelet (Figure 3, Table 1) and *Allogona profunda*, Broad-banded Forestsnail (COSEWIC *in press*). Sites surveyed were mainly small remnants of forest in parks and conservation areas. Living snails and empty shells were searched for visually using a meandering transect on the surface of the ground and under logs, rocks and similar debris. Because Proud Globelet is a relatively large species, it is less likely to have been overlooked than smaller snail species during these surveys; it was found only in the Black Oak Heritage Forest and south of it on a former light industrial area. The snail searches in 2013 resulted in approximatively 210 stored-in-alcohol samples of about 60 species being deposited at the Biodiversity Institute of Ontario (BIO) at Guelph and included in the Barcode of Life Database (BOLD); 200 shell samples of about 40 species also were collected and are currently being curated by Robert Forsyth.

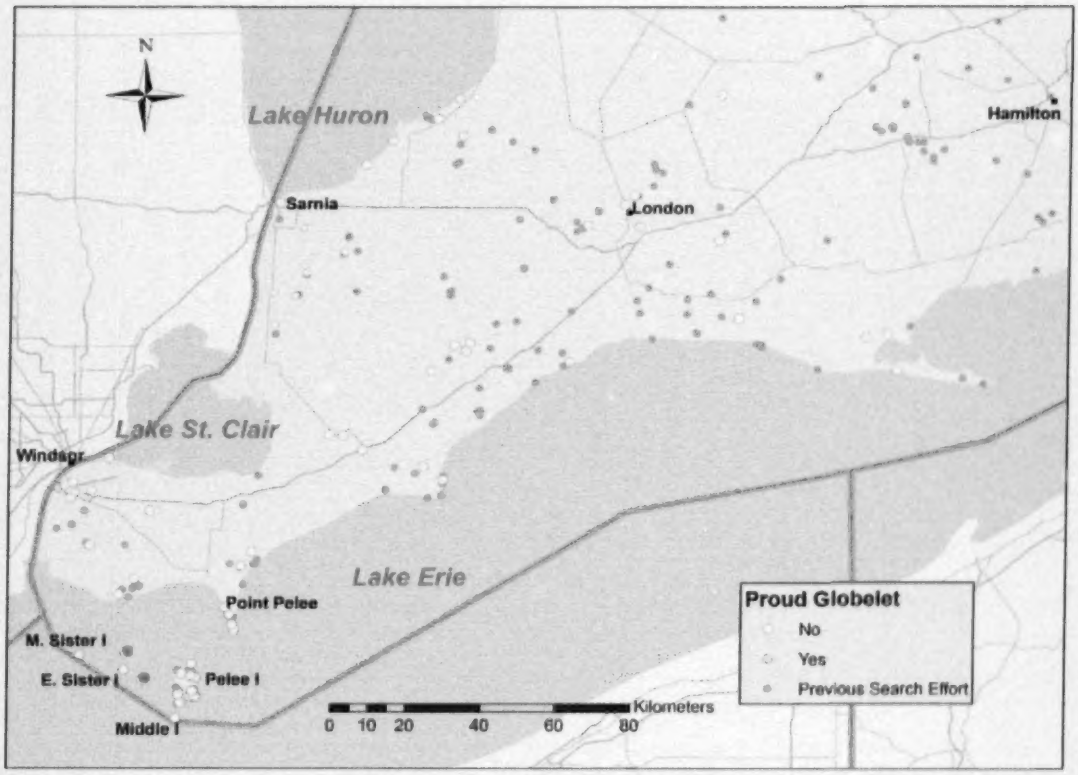

Figure 3. Map of southwestern Ontario showing the search effort for Proud Globelet (*Patera pennsylvanica*). Grey dots: sites surveyed between 1992 and 2012 by M.J. Oldham and A. Nicolai for terrestrial gastropods and white dots: sites surveyed in 2013 specifically targeting *P. pennsylvanica* unsuccessfully (no Proud Globelets found). Green dot: successfully surveyed sites in 2013 targeting *P. pennsylvanica*.

HABITAT

Habitat Requirements

In the U.S., Proud Globelet generally occurs on wooded hillsides or in ravines, under leaf litter and stones, but also on grassy roadsides (Hubricht 1985). The habitat of the Canadian population is sandy oak forest and a disturbed former light industrial site with building rubble.

The minimal viable habitat patch size for a Proud Globelet population is unknown. In Canada, only a single population of Proud Globelet is known and it is/was confined to a small area in a landscape where natural habitat is highly fragmented. It is unclear what factors caused the apparent disappearance of the population.

Food requirements for Proud Globelet are unknown. Fungi associated with decomposing logs on the forest floor are apparently an important source of food in other Polygyridae (Blinn 1963; Asami 1993). Occasionally some species of Polygyridae appear to be carnivorous (Simpson 1901; Crabb 1928). To counteract cholesterol shortages that occur during reproduction and aestivation, snails can also feed on carrion (Nicolai *et al.* 2011, 2012). *Patera appressa* requires fresh plant material in addition to leaf litter to increase growth rate and fitness (Martin and Bergey 2013). According to van Cleave and Foster (1937) as well as Steensma *et al.* (2009), stinging nettles (*Urtica* spp.) seem to be an important nutrient source for rapid early juvenile growth and higher fitness in other polygyrids.

Although habitat requirements seem to be similar within the Polygyridae, differences in for example, foraging habits, daily activity patterns, thermal physiology adaptation/plasticity, among species of the same genus can result in different habitat preferences (Walsh and Coles 2006).

Habitat Trends

Pre-European settlement land cover in southwestern Ontario was dominated by deciduous forest (72%) of which less than 10% were oak forests (Butt *et al.* 2005). Forest cover is now reduced to 16% in southwestern Ontario, and many oak forests have disappeared or are reduced in size (Butt *et al.* 2005). Only about 5% of the original forest cover remains in Essex County (ERCA 2002). Many forest remnants might be smaller than the minimal viable habitat patch size for some gastropods. The reduction and fragmentation of habitat could also have led to a decrease in population size accompanied by a loss of genetic diversity affecting the viability of populations.

The biodiversity of oak forests is unique, and Proud Globelet appear to be sensitive to the anthropogenic disturbances that drive biodiversity changes. In the study by Douglas *et al.* (2013) in Kentucky, the absence of natural *Patera appressa* populations was a good indicator of anthropogenic disturbance through its affinity for old growth, undisturbed forests. In the area of the Black Oak Heritage Forest in Windsor where the shells of Proud Globelet were found, old, weathered shells of the native Whitelip (*Neohelix albolabris*) were also abundant (Appendix 2). However, no live individuals of this species were recorded. The shells were about the same age as the Proud Globelet, and both species might have disappeared at the same time for the same unknown reason. Changes in vegetation affect snails as they use it as habitat, food and winter refugia. The presence of invasive species and the decline of native species change the ecological functioning of the habitat. The absence of live Proud Globelet and Whitelip might indicate a high degree of anthropogenic land use disturbance.

The Black Oak Heritage Forest is a forest remnant with several oak species (Pratt 2012). At the end of the 20th century, recreational use within this forest increased, as evidenced by the appearance of a trail system and the accumulation of garbage (Pratt pers. comm. 2013). At its periphery, urbanization and industrialization have fragmented the habitat (e.g., the railway) and changed environmental factors through soil and air pollution and changes in soil composition, hydrology and light conditions. For example, about 20 years ago a wood dump site (Figures 4 and 5) was installed on the south border of the forest by the City of Windsor (Pratt pers. comm. 2013), which changed habitat conditions and community composition through the introduction of new species. Even though the installation of the wood dump coincides with the first record of Proud Globelet, it is unlikely that snails migrated from the wood dump to the park. The trees in the wood dump came from city-owned land, including parks, road verges and woods, and were the result of urban forestry practices such as thinning, pruning, and removal of hazardous trees. Many of the trees transported to the wood dump are still well preserved, and do not host any woodland gastropod species.

Climate change is also expected to have a large impact on forest ecosystems. The following responses are possible if climatic conditions change beyond the tolerances of species: shifts in timing of life-cycle events; shifts in range boundaries; changes in morphology, reproduction, or genetics; or extinction (Rosenzweig *et al.* 2007). The consequence of climate change for snail habitat is a general disturbance of ecosystem processes.

BIOLOGY

Almost no information is available about the biology of Proud Globelet. General aspects of terrestrial snail biology are provided by the review of Barker (2001). Some information on the biology of other Polygyridae should only be considered as likely to be similar in Proud Globelet.

Life Cycle and Reproduction

Proud Globelet is an air-breathing (pulmonate), simultaneous hermaphrodite, egg-laying snail (Pilsbry 1940). In general, both members of a mating pair exchange sperm and produce eggs. Mating processes are very species-specific in snails, sperm being exchanged externally in the polygyrid *Mesodon* genus (Webb 1954). In most snail species, larger individuals lay more eggs than smaller ones (Heller 2001). Mating in Polygyridae occurs in fall or early spring and oviposition in spring to late summer (van Cleave and Foster 1937; Blinn 1963; Steensma *et al.* 2009). Egg clutches are deposited in shallow holes excavated in moist soil. Clutch size in Polygyridae ranges between 20 and 80 eggs that hatch about 20 to 60 days after oviposition, depending on temperature and moisture.

Growth occurs only during periods of activity (spring to fall), and snails reach their adult shell size after 1 to 2 years. Growth rate is extremely variable within a population, resulting in highly divergent adult sizes. The average annual growth rate ranges from 0.6 to 5.2 mm/month (as measured by shell breadth). Growth rate is highest in summer and fall, but depends also on population density. Sexual maturity is reached after 2 to 3 years and lifespan has been estimated to range between 3 and 5 years (based on studies by Stiven and Foster 1996 and Steensma *et al.* 2009 of related species of Polygyridae), which is the estimated generation time for Proud Globelet.

Hibernation in Polygyridae extends from early October until mid-April in the temperate region (Blinn 1963). Typical hibernation refugia are shallow depressions in the forest floor covered with leaf litter or at soil depths of 5 to 10 cm (Pearce and Örstan 2006). During hibernation the shell aperture is oriented upwards and sealed with a calcareous epiphragm in other Polygyridae (Blinn 1963); Nicolai (pers. obs.) also photographed an *A. profunda* in Canada with an epiphragm. Aestivation occurs occasionally during periods of prolonged heat and drought. During aestivation, snails usually stay inactive in moist microhabitats, such as in soil, under leaf litter, and under logs.

Polygyridae can be active both day and night, but often retire to shelter under leaf litter from mid-morning until late afternoon (Blinn 1963). However, most of them are crepuscular or nocturnal, and sympatric species often have different activity patterns (Asami 1993).

Physiology and Adaptability

Physiological responses to environmental factors and their plasticity and adaptability have not been investigated in Proud Globelet, nor in Polygyridae. In general, snails require calcium for shell formation. Soil and bedrock calcium availability influence the snail species richness of an area (Nekola 2005) and physiological processes, such as heat resistance in eggs (Nicolai *et al.* 2013). Heavy metals and pesticides in the soil are accumulated in tissues and may disturb physiological processes (Barker 2001).

Snails in regions with prolonged periods of drought and heat generally aestivate in buffered refuges and seal their shell aperture to avoid evaporation (Barker 2001; Pearce and Örstan 2006). In temperate regions, many species aestivate only in extreme summer conditions for a short period and have developed biochemical stress reactions that protect cells and maintain survival mechanisms, such as membrane fluidity, osmoregulation and enzyme activity (Nicolai *et al.* 2011). Unusually long heat and drought periods increase mortality.

Snails are ectotherms and prone to freezing in winter. Different strategies that are more or less plastic have evolved to enable survival at sub-zero temperatures and were reviewed in snails by Ansart and Vernon (2003). Because snails hibernate in the soil or the leaf litter, they rely on snow cover for optimal temperature buffering in temperate regions (Nicolai *et al.* 2011). Mortality during hibernation is around 40% in some populations and drives population dynamics (Peake 1978; Cain 1983).

Many terrestrial gastropods can be reared in captivity with relative ease (see Ansart *et al.* 2014 for a broad study involving short-term rearing of over 30 different species). The long-term success of rearing depends on the knowledge of species' specific requirements and has not been tested yet in Proud Globelet.

Dispersal and Migration

Active dispersal distances are unknown for Proud Globelet, but Polygyridae of similar size move between 120 and 220 cm per day within a home range of 80 to 800 m^2, measured with the spooling technique (Pearce 1990). In contrast, mark-recapture methods used for short-term observations underestimate the capacity for movement in snails because many species are homing, e.g., Blinn (1963) found marked snails at distances of 1 to 4 m from hibernation sites. Edworthy *et al.* (2012) observed a maximum dispersal of 32.2 m over a 3-year study in the polygyrid *Allogona townsendiana* (Oregon Forestsnail).

The fragmented state of oak forests in the Windsor area due to urban and industrial development as well as roads makes the potential for dispersal among suitable habitat patches unlikely should additional subpopulations exist. Eggs and immature stages are not known to be dispersed by wind, water, or other vectors.

Some terrestrial gastropods can be easily transported by human activity (e.g., cars, horticultural or agricultural products) and therefore be introduced to new habitats (Robinson 1999; Robinson and Slapcinsky 2005). There is no evidence that Proud Globelet is synanthropic or has been transported by humans.

Interspecific Interactions

Polygyridae have been noted to be one of the intermediate hosts of the meningeal worm *Parelaphostrongylus tenuis* (Rowley *et al.* 1987). Parasitic mites are also common in snails, in general. The infection rate within a population ranges between 45-75%. Depending on the mite species, infections can cause high mortality, reproduction perturbations, and reduced cold hardiness (Baur and Baur 2005). Parasites could therefore be a potential threat, especially in combination with other environmental factors, such as climate change or pollution.

Predation can be a source of mortality for land snails and potential predators have been reviewed by Jordan and Black (2012): "Gastropods are an important food source to a vast number of species, including salamanders, frogs, toads, turtles, snakes, lizards, birds, shrews, voles, moles, rats, mice, chipmunks, and squirrels. Invertebrate predators of terrestrial mollusks include sciomyzid fly larvae, firefly larvae, parasitic wasp larvae, carabid and staphylinid beetles, ants, spiders, and harvestmen." Introduced predator species or an increase in abundance of native predators due to ecological disturbance can therefore be a potential threat.

Competition with other terrestrial gastropods including exotic species is not documented in the literature but is a potential threat (Whitson 2005; Grimm *et al.* 2010).

POPULATION SIZES AND TRENDS

Sampling Effort and Methods

In addition to the sampling effort of 1992 and 1996 where fresh, empty shells of recently dead Proud Globelets were found in the south part of the Black Oak Heritage Forest, a total of 17 person-hours of search effort were spent in 2013 in and near this forest (Table 1). The whole forest (north and south part) was searched with an effort of 6 person-hours (Table 1 and Appendix 2). Shells were found only on a small plot at the south border of the forest; one shell also was found further south of the forest in a former light industrial area. In order to increase the probability of encountering live individuals of Proud Globelet, intensive sampling was conducted in the 200 m x 100 m plot in the forest where the shells were initially found with an effort of 14 person-hours (Figure 4, Appendix 2) in different light and weather conditions: (i) warm-humid at dawn, (ii) warm-humid during the morning, (iii) warm-rainy at midday, and (iv) warm-rainy at night. The forest plot was searched using a meandering transect by lifting logs and debris and occasionally digging 5 cm deep in the soil on a surface of 50 cm x 50 cm. Additionally, all observed snails and slugs were collected in the leaf litter and in the first few centimetres of the soil on one square (10 m x 10 m) (Figures 4 and 6) under condition (i) and on one transect under condition (iii). The wood dump of the City of Windsor was also searched. The former light industrial area (Figure 4) was searched as part of a 3 person-hour survey following a transect from the south part of the Black Oak Heritage Forest across the wood dump. The single shell of Proud Globelet was found with other live and dead shells of other snail species in an area estimated to be less than 100 sq. metres.

In total 15 empty, old, weathered shells from juveniles and adults were recorded in this area in 2013. Voucher specimens (shells) were submitted to Robert Forsyth to confirm identification and for curation as well as to Jean-Marc Gagnon of the CMN (Appendix 1). All shells have lost their periostracum (outer protein layer) and the mineral structure was altered (Figure 1). They were estimated to be between 5 and 15 years old following Pearce (2008); shells older than 15 years generally fall into pieces and disintegrate (Nicolai pers. obs.).

Black Oak Heritage Forest, south part
Search area using meander transect with records CMNML 096170, 096171 and 096184
Search square

A

Black Oak Heritage Forest, south part
Search area using meander transect with records CMNML 096170, 096171 and 096184
Search square

B

Figure 4. Search area (yellow) and search square (pink) for live individuals in the south part of the Black Oak Heritage Forest in Windsor, Essex County (green), represented on aerial photographs from 2011 (A) and 1999 (B). The intensive search area corresponds to the zone where shells were found in 1992 (CMNML 096171) and 1996 (CMNML 096170) by M.J. Oldham, and on May 3, July 28 and August 27 (CMNML 096184), 2013 by A. Nicolai (see Appendix 1 and 2). The intensive search area is located close to the bordering wood dump (blue) managed by the City of Windsor. One shell was found on September 5, 2013 by M.J. Oldham (# 41549) south of Black Oak Heritage Forest on a former light industrial area (orange). All records are from habitats that have not substantially changed since 1999. Aerial imagery containing point locations has been removed. Contact the COSEWIC Secretariat for access.

Figure 5. Wood dump operated by the City of Windsor, Essex County, bordering the south part of the Black Oak Heritage Forest. View of the south entrance of the park with the wood dump on the right side. (Photo credit: Annegret Nicolai.)

Figure 6. Square (10 m x 10 m, flagging tape can be seen on two edges) for the intensive search for live individuals of the Proud Globelet (*Patera pennsylvanica*) in the zone of shell occurrence in the Black Oak Heritage Forest in the City of Windsor. (Photo credit: Annegret Nicolai.)

Abundance

Because no live individual has ever been found in Canada, no estimation of abundance of mature individuals can be made. Despite intensive survey efforts only 15 shells were found in 2013, presumably indicating a low level of abundance in the last 15 years. No abundance data are available for other populations of this snail in the U.S.

Fluctuations and Trends

Because no live individuals nor fresh shells of recently dead individuals, as in 1992 and 1996 (see photo on cover page), were found in 2013, population size could not be estimated. The complete absence of live individuals and the age of the shells found in 2013 suggest that the population has substantially declined since 1996, and there is a strong likelihood that Proud Globelet has disappeared from this forest and from Canada as it has only ever been found in and near this forest in southwestern Ontario (see **Search Effort**, Table 1, Figure 3).

Rescue Effect

Rescue is unlikely. Natural dispersal from populations in Michigan across the Detroit River is probably rare or non-existent. NatureServe (2013) considers permanent water bodies greater than 30 m wide a dispersal barrier for terrestrial gastropods, and the Detroit and St. Clair rivers and Lake Erie would be formidable barriers to dispersal from adjacent U.S. states.

THREATS AND LIMITING FACTORS

Threats

Because no live individuals or fresh shells of recently dead individuals were found in 2013, the threats calculator (IUCN and CMP 2006; Master *et al.* 2009) would be difficult to apply as the "scope" and "severity" of the various threats would most likely be "unknown". Scope is the proportion of the species' total population that would be expected to be affected by a specific threat within the next 10 years. Severity is the anticipated population reduction in the next 10 years or 3 generations, whichever is longer, of that portion of the population that is exposed to the specific threat. Threats from the past or ongoing threats that probably contributed to the apparent disappearance of the Canadian population and that were observed in the Black Oak Heritage Forest are as follows, using the IUCN and CMP nomenclature and numbering.

Transportation and service corridors

A railway crosses the Black Oak Heritage Forest. In the past, the construction of this railroad might have contributed to the decline of the species by the local increase in mortality during construction, maintenance, and operations. Representing a barrier for snails (Baur and Baur 1990) the railway also fragmented the habitat, potentially reducing gene flow, if the population had occupied the entire forest.

A new bridge crossing the Detroit River is expected to be built connecting Highway 75 in Detroit with Highway 401 in Windsor (Figure 7). The New International Trade Crossing or Detroit River International Crossing project is mainly for transportation of goods between Canada and the USA. The connecting Highway 3 between the new bridge and the existing Highway 401 in Windsor is just north of the Black Oak Heritage Forest and the Ojibway Prairie Complex (Figure 7). Although the road, customs inspection plaza and the bridge construction will not directly affect or fragment Proud Globelet habitat, air- and water-borne pollution (e.g., heavy metals and road salt) could significantly increase in the forest due to the expected increase in traffic volume in the area.

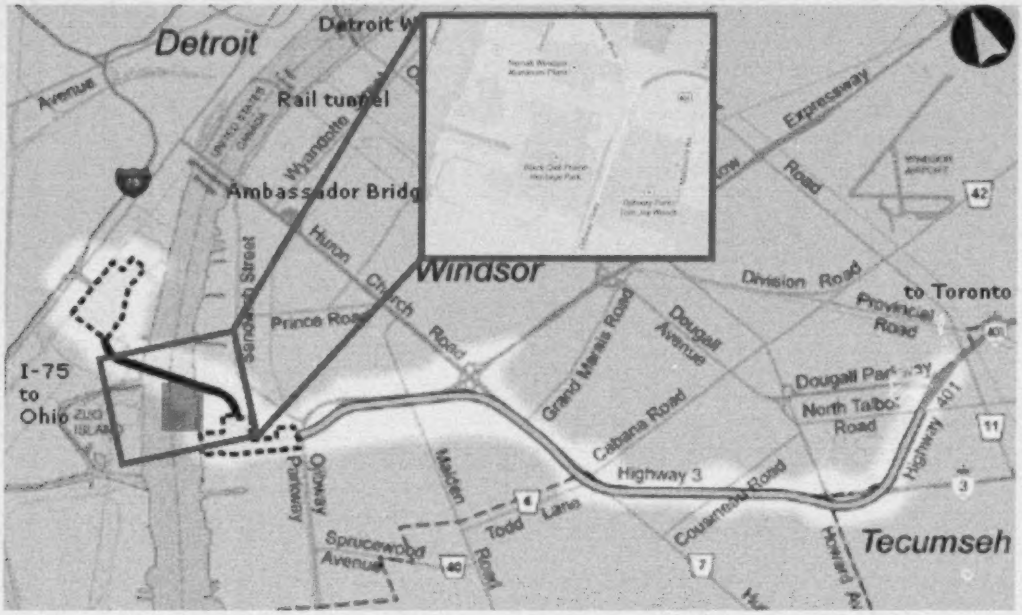

Figure 7. The new bridge crossing the Detroit River and connecting Highway 75 in Detroit with Highway 401 in Windsor. The construction site in Windsor (blue with dashed line within the red rectangle) is located just north of the Black Oak Heritage Forest (red transparent square within the red rectangle) (modified from Samuel 2009).

Human intrusions and disturbances

The Black Oak Heritage Forest has a high trail density and is intensively visited for recreation (Pratt pers. comm. 2013), but no data on visitor numbers and activities are available. No management plan has been implemented. Trampling by pedestrians is a known threat for some snail species (Baur and Baur 1990; Charrier *et al.* 2012) and large trails, roads, or railways represent barriers.

Natural system modifications

The wood dump at the south border of the Black Oak Heritage Forest has changed habitat conditions and might be a source of introduced plant and animal species that have and could further change habitat conditions, and could potentially increase predation or competition.

Urbanization and construction at the periphery of the Black Oak Heritage Forest has destroyed and fragmented the habitat. Construction and then demolition of the light industrial facilities are also likely to alter soil composition, structure and hydrology and have a large impact on snail physiology or behaviour and general ecosystem functioning (Charrier *et al.* 2012). For instance, changes in soil pH can interfere with calcium absorption, changes in soil structure can alter dormancy refuges or nest conditions for reproduction, and drier soil reduces activity periods and therefore foraging and reproduction. All habitat alterations could have direct consequences on fitness and population dynamics.

Invasive plant species occur throughout southwestern Ontario. Some invasive species are thought to have contributed to declines in larger species of land snails, possibly by altering soil nutrient cycles (Stoll *et al.* 2012).

Among non-native animals, earthworms have one of the greatest impacts on forest ecosystems throughout Canada by altering nutrient distributions, soil pH, soil fauna, and understorey vegetation (Addison 2008). Earthworms reduce leaf litter accumulation and could alter terrestrial snail communities that use leaf litter as habitat (Norden 2010). In the Black Oak Heritage Forest, there were patches of bare earth and just coarse, woody debris, which could be a result of invasive earthworms.

Competition with exotic terrestrial gastropods is a potential threat (Whitson 2005; Grimm *et al.* 2010). The abundance of introduced slug species of the genus *Arion* in both Proud Globelet occurrence sites was high. The Dusky Arion (*Arion subfuscus*) was found in the leaf litter and under logs, but especially on fungus in the forest (Figure 8). Dusky Arion and Proud Globelet could compete for fungi as a food source. Grey Fieldslug (*Deroceras reticulatum*), Grovesnail (*Cepaea nemoralis*) and Heath Snail (*Xerolenta obvia*), three other introduced gastropods, are also abundant and found in the same areas where shells of Proud Globelet were found. Remarkably, the snails in the former light industrial area appeared to be localized and restricted to a small area less than approximately 100 m^2 but there were thousands of empty *X. obvia* shells and dozens to hundreds live *X. obvia*; this

was also the first record for this species in southwestern Ontario, it previously only being known in south-central Ontario as early as 1969 (Grimm *et al.* 2010). It was discovered in a railway yard in nearby Detroit in 2001 (Grimm *et al.* 2010). As there is a railway line in and adjacent to the Black Oak Heritage Forest, it could be a recent introduction into southwestern Ontario. These other exotic species could be competitors for habitat and other food sources; however, it is difficult to estimate their actual direct impacts on Proud Globelet. The gastropod composition in and around the Black Oak Heritage Forest has definitely changed, including the probable recent disappearance of Proud Globelet and Whitelip *Neohelix albolabris*, but it is unclear if inter-specific competition or other environmental factors were the drivers of this change.

Figure 8. Dusky Arion (*Arion subfuscus*) foraging on a fungus in Black Oak Heritage Forest, Windsor, Essex County. (Photo credit: Annegret Nicolai.)

Pollution

The high degree of industrialization surrounding the Black Oak Heritage Forest suggests some level of soil, water and air pollution. As xenobiotics are generally accumulated in snail tissues (Barker 2001), the pollution of the site (e.g., salts, heavy metals, artificial organic compounds) might have an impact on Proud Globelet. Acid rain in the area is likely to influence the calcium uptake by snails.

Additionally, garbage dumped in some parts of the forest can lead to local increases in organic and inorganic levels of pollution. Charrier *et al.* (2013) mentioned the ingestion of small plastic pieces as a potential threat for gastropods, because it could lead to increased mortality. Alternatively, cardboard and other garbage could increase the availability of moist refuges.

Climate change and extreme weather

Climate change can have a large impact on ecosystem processes thereby changing habitat conditions for Proud Globelet, or directly affect snail survival. In temperate regions, climate change will involve increases in both average temperatures and the frequency of extreme weather events such as heat waves, drought and increased precipitation (Della Marta *et al.* 2007). For instance, heat waves and drought could cause high mortality due to heat or dehydration stresses (Nicolai *et al.* 2011). Ongoing climate change will disproportionately alter winter conditions (IPCC 2007). The northern distributions of many species are currently thought to be set by winter conditions, so warmer winters could lead to range expansion if suitable habitat exists. Conversely, interactions between climate and microclimate could also result in more adverse conditions, for instance the absence of snow cover induces a decrease of soil temperature accompanied by day/night fluctuations that might affect the survival of species with low cold tolerance plasticity. High temperatures in early spring could lead to arousal, and the following low temperatures could increase mortality. During several years between 1996 and 2013, high temperatures were recorded in March and April followed by extreme low temperatures, e.g., March 1998: highest temperature 22.4°C, lowest temperature -15.9°C (Climate Canada 2014).These abnormal temperature extremes could have contributed to the population decline.

Limiting Factors

Limiting factors for terrestrial snails include (i) low dispersal or escape capacity, (ii) relatively long generation time, (iii) low physiological resistance to fluctuating environmental factors, such as temperature and humidity, (iv) susceptibility to bioaccumulation of toxic xenobiotics, and (v) limited genetic flow.

Number of Locations

Canada's only population of Proud Globelet is/was in and south of the Black Oak Heritage Forest of the City of Windsor. Given the small size of the occupied habitat where a single event could soon affect all individuals of a taxon present, there are only one or two locations following IUCN criteria (IUCN 2001): Black Oak Heritage Forest and the former light industrial area near the forest.

PROTECTION, STATUS AND RANKS

Legal Protection and Status

Proud Globelet is not protected by any legislation, regulations, customs or conditions nationally or worldwide. COSEWIC assessed this wildlife species as Endangered in May 2015. It is not listed under the U.S. *Endangered Species Act* or under any state acts (US Fish and Wildlife Service 2013). It is not listed under the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES 2013).

Non-Legal Status and Ranks

Proud Globelet is not listed by IUCN (2013). NatureServe (2013) provides the following ranks.

Global Rank: G4
National Rank (Canada): N1
National Rank (US): N4

Sub-national ranks (S-ranks) in Canada and the U.S. are as follows:

Canadian provinces where Proud Globelet occurs
Ontario: S1 (NHIC 2013). Acts of Ontario do not provide legal protection.

US states adjoining southwestern Ontario
Michigan: SNR and SC (Michigan Natural Features Inventory 2013)
Pennsylvania: S1S2 (Pennsylvania Natural Heritage Program 2013)
Ohio: SNR (Ohio Department of Natural Resources 2012)
New York: not present (Hubricht 1985; Schlesinger 2013)

Other U.S. states where Proud Globelet occurs
Iowa: SNR (Natural Resource Commission Iowa 2009)
Illinois: SNR (Cummings and Phillips 2013)
Indiana: SNR (Indiana Department of Natural Resources 2013)
Kentucky: SNR (Kentucky State Nature Preserve Commission 2013)
West Virginia: S1 (West Virginia Natural Heritage Program 2012)
Missouri: SNR (Missouri Department of Conservation 2014)

(G4 - apparently secure, N1 - critically imperilled nationally, N4 - apparently secure. SNR – not ranked sub-nationally, SC – special concern (at the state level), S1 - critically imperilled sub-nationally, S2 - imperilled sub-nationally, S3 – vulnerable sub-nationally, S4 – apparently secure sub-nationally)

Habitat Protection and Ownership

The Black Oak Heritage Forest is owned and protected by the City of Windsor. Access is granted for recreational use. There is no particular management strategy. Changes to the forest are possible under future urban planning.

Although the former light industrial area south of the Black Oak Heritage Forest has remained undeveloped since at least 1999 (Figure 4), the land is available for industrial construction at any time. Therefore if any live Proud Globelet remain in the area, they would be susceptible to potential further habitat loss.

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INFORMATION SOURCES

Addison, J.A. 2008. Distribution and impacts of invasive earthworms in Canadian forest ecosystems. Biological Invasions 11:59-79.

Anderson, F.E. 2007. Population genetics of the carinate pillsnail, *Euchemotrema hubrichti*: genetic structure on a small spatial scale. Conservation Genetics 8:965-975.

Ansart, A., A. Guiller, O. Moine, M-C. Martin, and L. Madec. 2014. Is cold hardiness size-constrained? A comparative approach in land snails. Evolutionary Ecology 28:471-493.

Ansart, A., and P. Vernon. 2003. Cold hardiness in molluscs. Acta Oecologica 24:95-102.

Asami, T. 1993. Divergence of activity patterns in coexisting species of land snails. Malacologia 35:399-406.

Barker, G.M. 2001. The Biology of Terrestrial Molluscs. CABI Publishing New York, 558 pp.

Baur, A., and B. Baur. 1990. Are roads barriers to dispersal in the land snail *Arianta arbustorum*? Canadian Journal of Zoology 68:613-617.

Baur, A., and B. Baur. 2005. Interpopulation variation in the prevalence and intensity of parasitic mite infection in the land snail *Arianta arbustorum*. Invertebrate Biology 124(3):194-201

Blinn, W.C. 1963. Ecology of the land snails *Mesodon thyroidus* and *Allogona profunda*. Ecology 44:498-505.

Butt, S., P. Ramprasad, and A. Fenech. 2005. Changes in the landscape of Southern Ontario, Canada since 1750: Impacts of European colonization. Pp. 83-92. *In* A. Fenech, A., D. MacIver, H. Auld, and R. Hansell (eds.). Integrated Mapping Assessment. Environment Canada, Toronto, Ontario, Canada, 186 pp.

Cain, A.J. 1983. Ecology and ecogenetics of terrestrial molluscan populations. Pp. 597-647 *In* W.D. Russel Hunter (ed.). The Mollusca, Volume VI. Academic Press, New York. 695 pp.

Charrier, M., A. Nicolai, M.-P. Dabard, and A. Crave. 2013. Plan National d'Actions de *Tyrrhenaria ceratina*, escargot terrestre endémique de Corse. *National Recovery Plan*, Ministry of Ecology, Energy, Sustainable Development and the Ocean (ed.), 92 pp.

Churchfield, S. 1984. Dietary separation in three species of shrew inhabiting water-cress beds. Journal of Zoology 204:211–228.

CITES. 2013. Convention on international trade in endangered species of wild fauna and flora. Web site: http://www.cites.org [accessed November 14, 2013].

Clapp, G.H. 1916. Notes on the land shells of the islands at the western end of Lake Erie and description of new varieties. Annals of the Carnegie Museum 10:532-540.

Climate Canada. 2014. Monthly Data Report for Windsor 1940-2013. Web site: http://climate.weather.gc.ca/climateData/monthlydata_e.html?timeframe=3&Prov=ON&StationID=4716&mlyRange=1940-01-01|2013-12-01&Year=1996&Month=01&Day=01 [accessed December 22, 2014].

Coppolino, M.L. 2009. Land Snails of Southern Illinois. Southern Illinois University, Carbondale, Illinois, USA. Web site: http://mypage.siu.edu/mlcopp [accessed December 18, 2013].

COSEWIC. 2011. Guidelines for recognizing designatable units. Web site: http://www.cosewic.gc.ca/eng/sct2/sct2_5_e.cfm [accessed December 06, 2013].

COSEWIC. *In press*. COSEWIC assessment and status report on the Broad-banded Forestsnail *Allogona profunda* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. xx pp.

Crabb E.D. 1928. A predatory *Polygyra*. Nautilus 42:35-36.

Cummings, K., and C. Phillips. 2013. Mollusca of Illinois. Illinois Natural History Survey. Prairie Research Institute. University of Illinois at Urbana-Champaign. Web site: http://wwx.inhs.illinois.edu/collections/mollusk/data/mollusca-of-illinois [accessed November 20, 2013].

Della Marta, P.M., J. Luterbacher, H. von Weissenfluh, E. Xoplaki, M.Brunet, and H. Wanner. 2007. Summer heat waves over western Europe 1880-2003, their relationship to large-scale forcings and predictability. Climate Dynamics 29:251-275.

Douglas, D.D., D.R. Brown, and N. Pederson. 2013. Land snail diversity can reflect degrees of anthropogenic disturbance. Ecosphere 4:28.

Edworthy, A.B., K.M.M. Steensma, H.M. Zandberg, and P.L. Lilley. 2012. Dispersal, home-range size, and habitat use of an endangered land snail, the Oregon forestsnail (*Allogona townsendiana*). Canadian Journal of Zoology 90(7):875-884.

Emberton, K.C. 1991. The genitalic, allozymic and conchological evolution of the tribe Mesodontini (Pulmonata: Stylommatophora: Polygyridae). Malacologia 33(1–2): 71–178.

ERCA (Essex Region Conservation Authority). 2002. Essex Region Biodiversity Conservation Strategy - Habitat Restoration and Enhancement Guidelines (Comprehensive Version). Dan Lebedyk, Project Co-ordinator. Essex, Ontario. 181 pp.

Forsyth, R.G. 2012. General status of terrestrial molluscs of Canada. Spreadsheet containing a list of and Canadian and provincial or territorial general status ranks. Prepared for the General Status of Wildlife Species 2015 project. 11 December 2012.

Forsyth, R. 2013. Terrestrial molluscs of Canada online database: Bibliography of the terrestrial molluscs of Canada. Web site: http://www.mollus.ca/ [accessed June 10, 2013].

Frest, T.J., and E.J. Johannes. 1995. Interior Columbia Basin mollusk species of special concern. Deixis Consultants, Seattle, Washington. Prepared for the U.S. Department of Agriculture, Forest Service; U.S. Department of the Interior, Bureau of Land Management, Upper Columbia River Basin Ecosystem Management Project. 274 pp. + appendices.

GBIF. 2013. Global Biodiversity Information Facility. Web site: http://www.gbif.org/ [accessed November 10, 2013].

Goodrich, C. 1916. A trip to the islands in Lake Erie. Annals of the Carnegie Museum 10:527-531.

Grimm, F.W. 1996. Terrestrial molluscs. *In* I.M. Smith, Assessment of species diversity in the Mixedwood Plains ecosystem. Ecological Monitoring and Assessment Network. Web site: http://www.naturewatch.ca/Mixedwood/landsnai/lsnail8.htm [accessed November 20, 2013].

Grimm, F.W., R.G. Forsyth, F.W. Schueler, and A. Karstad. 2010. Identifying Land Snails and Slugs in Canada: Introduced Species and Native Genera. Ottawa: Canadian Food Inspection Agency. 168 pp.

Heller, J. 2001. Life history strategies. Pp. 413-445. *In* G.M. Barker (ed.). The Biology of Terrestrial Molluscs. CABI Publishing New York, 558 pp.

Hubricht, L. 1985. The distributions of the native land mollusks of the Eastern United States. Fieldiana Zoology 24:47-171.

Indiana Department of Natural Resources. 2013. Indiana's state endangered species. Web site: http://www.in.gov/dnr/fishwild/files/fw-Endangered_Species_List.pdf [accessed November 20, 2013].

IPCC. 2007. Climate Change 2007: Synthesis Report. Core Writing Team, R.K. Pachauri. and A. Reisinger (eds.). International Panel on Climate Change, Geneva, Switzerland. 104 pp.

IUCN. 2001. The IUCN Red List of Threatened Species - 2001 Categories & Criteria (version 3.1). Web site: http://www.iucnredlist.org/static/categories_criteria_3_1 [accessed January 08, 2014].

IUCN. 2013. The IUCN Red List of Threatened Species. Web site: www.redlist.org/ [accessed November 14, 2013].

IUCN and CMP (International Union for Conservation of Nature and Conservation Measures Partnership). 2006. IUCN – CMP unified classification of direct threats, version 1.0 – June 2006. Gland, Switzerland. 17 pp. Available at: http://www.conservationmeasures.org/initiatives/threats-actions-taxonomies/threats-taxonomy

Jennings, T.J., and J.P. Barkham. 1979. Litter decomposition by slugs in mixed deciduous woodland. Holarctic Ecology 2:21-29.

Jordan S.F., and S.H. Black. 2012. Effects of Forest Land Management on Terrestrial Mollusks: A Literature Review. USDA Forest Service, Region 6 USDI Oregon/Washington, Bureau of Land Management. 87 pp.

Kentucky State Nature Preserve Commission. 2013. Endangered, threatened, and special concern plants, animals, and natural communities of Kentucky with habitat description. Web site: http://naturepreserves.ky.gov/pubs/publications/ksnpc_specieshabitat.pdf [accessed December 06, 2013].

Martin, R.J., and E.A. Bergey. 2013. Growth plasticity with changing diet in the land snail *Patera appressa* (Polygyridae). Journal of Molluscan Studies 79:364-368.

Martin, S.M. 2000. Terrestrial snails and slugs (Mollusca: Gastropoda) of Maine. Northeastern Naturalist 7:33–88.

Mason, C.F. 1970a. Food, feeding rates and assimilation in woodland snails. Oecologia 4:358–373.

Mason, C.F. 1970b. Snail populations, beech litter production, and the role of snails in litter decomposition. Oecologia 5:215–239.

Master, L., D. Faber-Langendoen, R. Bittman, G.A. Hammerson, B. Heidel, J. Nichols, L. Ramsay, and A. Tomaino. 2009. NatureServe conservation status assessments: factors for assessing extinction risk. NatureServe, Arlington, Virginia. 57 pp. Available at: http://www.natureserve.org/publications/ConsStatusAssess_StatusFactors.pdf

Michigan Natural Features Inventory. 2013. Michigan's special animals. Michigan State University Extension (ed.) Lansing, Michigan. 16 pp.

Missouri Department of Conservation. 2014. Missouri species and communities of conservation concern. Web site: http://mdc.mo.gov/sites/default/files/resources/2010/04/2014_species_concern.pdf [accessed January 06, 2014].

Natural Resource Commission Iowa. 2009. Endangered and threatened plant and animal species. IAC 571, Chapter 77. Web site: https://www.legis.iowa.gov/docs/ACO/chapter/571.77.pdf [accessed January 07, 2014].

NatureServe. 2013. NatureServe Explorer: An online encyclopedia of life. Version 7.1. NatureServe, Arlington, Virginia. Web site: http://www.natureserve.org/explorer [accessed: November 20, 2013].

Nekola, J.C. 2005. Geographic variation in richness and shell size of eastern North American land snail communities. Records of the Western Australian Museum Supplement No. 68:39–51.

NHIC. 2013. Mollusc species list. Website: Natural Heritage Information Centre, Ontario Ministry of Natural Resources. Web site: http://www.mnr.gov.on.ca/en/Business/NHIC/2ColumnSubPage/STDU_138223.html [accessed December 06, 2013].

Nicolai, A., J. Filser, R. Lenz, C. Bertrand, and M. Charrier. 2011. Adjustment of metabolite composition in the haemolymph to seasonal variations in the land snail *Helix pomatia*. Journal of Comparative Physiology B 181:457-466.

Nicolai, A., J. Filser, R. Lenz, V. Briand, and M. Charrier. 2012. Composition of body storage compounds influences egg quality and reproductive investment in the land snail *Cornu aspersum*. Canadian Journal of Zoology 90:1161-1170.

Nicolai, A., P. Vernon, R. Lenz, J. Le Lannic, V. Briand, and M. Charrier. 2013. Well wrapped eggs: Effects of egg shell structure on heat resistance and hatchling mass in the invasive land snail *Cornu aspersum*. Journal of Experimental Zoology A 319:63-73.

Norden, A.W. 2010. Invasive earthworms: a threat to eastern North American forest snails? Tentacle 18:29-30.

Nyffeler, M., and W.O.P. Symondson. 2001. Spiders and harvestmen as gastropod predators. Ecological Entomology 26:617-628.

Ohio Department of Natural Resources. 2012. Wildlife that are considered to be endangered, threatened, species of concern, special interest, extirpated, or extinct in Ohio. Publication 5356 (R1012). 10 pp.

Oughton, J. 1948. A Zoogeographical Study of the Land Snails of Ontario. University of Toronto Press, Toronto. 128 pp. plus maps, charts, diagrams.

Peake, J. 1978. Distribution and Ecology of the Stylommatophora. Pp. 429-526 *In* V. Fretter, and J. Peake (eds.). Pulmonates. Academic Press, London. 540 pp.

Pearce T.A. 1990. Spooling and line technique for tracing field movements of terrestrial snails. Walkerana 4(12):307-316.

Pearce, T.A. 2008. When a snail dies in the forest, how long will the shell persist? Effect of dissolution and micro-bioerosion. American Malacological Bulletin 26:111-117.

Pearce, T.A., and A. Örstan. 2006. Terrestrial gastropoda. Pp. 261-285. *In* C.F. Sturm, T.A. Pearce, and A. Valdés (eds.). The Mollusks: A Guide to Their Study, Collection, and Preservation. American Malacological Society, Pittsburgh, Pennsylvania. 445 pp.

Pennsylvania Natural Heritage Program. 2013. Species of Special Concern Lists. Web site: http://www.naturalheritage.state.pa.us/species.aspx [accessed December 06, 2013].

Pilsbry, H.A. 1940. Land Mollusca of North America (North of Mexico). Volume 1. Part 2. The Academy of Natural Sciences of Philadelphia, Philadelphia. 1113 pp.

Pratt, P.D. 2012. Provincially Rare Vascular Plants and Wildlife of the Ojibway Prairie Complex (Version nov2012). Ojibway Nature Centre. Department of Parks, Windsor, Ontario. Web site: http://www.ojibway.ca/raresp.htm [accessed April 20, 2013].

Pratt, P.D., pers. comm. 2013. *Email correspondence to A. Nicolai.* August 2013. Head Naturalist, Ojibway Nature Centre. Department of Parks, Windsor, Ontario

Robinson D.G. 1999. Alien invasions: the effects of the global economy on non-marine gastropod into the United States. Malacologia 41:413-438.

Robinson, D., and J. Slapcinsky. 2005. Recent introductions of alien gastropods into North America. American Malacological Bulletin 20:89-93.

Rosenzweig, C., G. Casassa, D.J. Karoly, A. Imeson, C. Liu, A. Menzel, S. Rawlins, T.L. Root, B. Seguin, and P. Tryjanowski. 2007. Assessment of observed changes and responses in natural and managed systems. Pp. 79-131. *In* M.L. Change, O.F. Parry, J.P. Canziani, P.J. Palutikof van der Linden, and C.E. Hanson (eds.). Climate Change 2007: Impacts, Adaptation and Vulnerability. Fourth Assessment Report of the Intergovernmental Panel on Climate, Cambridge University Press, Cambridge, UK. 986 pp.

Rowley M.A., E.S. Loker, J.F. Pagels, and R.J. Montali. 1987. Terrestrial gastropod hosts of *Parelaphostrongylus tenuis* at the National Zoological Park's Conservation and Research Center, Virginia. Journal of Parasitology 73:1084-1089.

Samuel P. 2009. US Gov freezes permitting for new span of Ambassador Bridge Detroit-Windsor. Web site: http://tollroadsnews.com/news/us-gov-freezes-permitting-for-new-span-of-ambassador-bridge-detroit-windsor [accessed December 18, 2014].

Schlesinger, M.D. 2013. Rare Animal Status List January 2013. New York Natural Heritage Program. Web site: www.nynhp.org. [accessed December 06, 2013].

Simpson, G.B. 1901. Anatomy and physiology of *Polygyra albolabris* and *Limax maximus*. Bulletin of the New York State Museum 40(8):237-313

South, A. 1980. A technique for the assessment of predation by birds and mammals on the slug *Deroceras reticulatum* (Müller) (Pulmonata: Limacidae). Journal of Conchology 30:229–234.

Steensma, K.M.M., P.L. Lilley and H.M. Zandberg. 2009. Life history and habitat requirements of the Oregon forestsnail, *Allogona townsendiana* (Mollusca, Gastropoda, Pulmonata, Polygyridae), in a British Columbia population. Invertebrate Biology 128:232-242.

Stiven, A.E., and B.A. Foster. 1996. Density and adult size in natural populations of a southern Appalachian low-density land snail, *Mesodon normalis* (Pilsbry). American Midland Naturalist 136 (2):287-299.

Stoll, P., K. Gatzsch, H. Rusterholz, and B. Baur. 2012. Response of plant and gastropod species to knotweed invasion. Basic and Applied Ecology 13:232-240.

Turgeon, D.D., J.F. Quinn, Jr., A.E. Bogan, E.V. Coan, F.G. Hochberg, W.G. Lyons, P. Mikkelsen, R.J. Neves, C.F.E. Roper, G. Rosenberg, B. Roth, A. Scheltema, F.G. Thompson, M. Vecchione, and J.D. Williams. 1998. Common and Scientific Names of Aquatic Invertebrates from the United States and Canada: Mollusks, Second Edition. American Fisheries Society Special Publication. 26. Bethesda, Maryland. 526 pp.

US Fish and Wildlife Service. 2013. Endangered Species. Web site: http://www.fws.gov/endangered/ [accessed November 14, 2013].

Van Cleave, H.J. and T.D. Foster. 1937. The seasonal life history of land snail *Polygyra thyroidus* (Say). Nautilus 51:50-54.

Walsh, G.E., and B.F. Coles. 2006. *Daedalochila lithica* and *Daedalochila dorfeuilliana* (Gastropoda : Polygyridae) in Arkansas, USA: morphology, distribution, and habitat. Nautilus 120(4):131-138.

Webb, G.R. 1954 Pulmonata, Polygyridae, Polygyrinae: the sexology and taxonomy of seven species of land-snails of the genus Mesodon. Gastropodia 1:19-20.

West Virginia Natural Heritage Program. 2012. Rare, threatened, and endangered animals. Web site: http://www.wvdnr.gov/Wildlife/PDFFiles/RTE_Animals_2012.pdf [accessed December 06, 2013].

Whitson, M. 2005. *Cepaea nemoralis* (Gastropoda, Helicidae): The Invited Invader. Journal of the Kentucky Academy of Science 66:82–88.

BIOGRAPHICAL SUMMARY OF REPORT WRITERS

Annegret Nicolai is a biologist at the Western Catholic University in Angers, France. She has a Ph.D. from the University of Bremen in Germany and from the University of Rennes 1 in France. Her research involves investigating eco-physiological questions in terrestrial snails, specifically about the impact of climate change and resource availability on the physiology and reproduction in endangered and invasive species. She also co-supervises a Ph.D. thesis analyzing the pathways of invasion of terrestrial gastropods and adaptation to climate change. She has very specific knowledge about the biology, anatomy, physiology and ecology of terrestrial gastropods. In Germany she developed a captive-breeding program for the protected *Helix pomatia* and in France she was co-author of the Species Report and the Recovery Strategy in *Tyrrhenaria ceratina* in Corsica. In the Sinclair lab at Western University, Ontario, she investigated the overwintering strategy of *Cepaea nemoralis*. Since 2012 she has been surveying terrestrial gastropods in Ontario and participating in the "barcoding of life" project at the University of Guelph. She became a member of the mollusc subcommittee of COSEWIC in 2014.

Michael J. Oldham has been a biologist with the Natural Heritage Information Centre, Ontario Ministry of Natural Resources (OMNR), for the past 20 years. Previously he worked for the OMNR and conservation authorities in Aylmer, Chatham, Essex, London, Richmond Hill, and Toronto. He has a B.Sc. in Biology from the University of Guelph and is a former member of COSEWIC and the COSEWIC Amphibians and Reptiles SSC and a current member of the Vascular Plants SSC. He also served for more than a decade on the provincial Committee on the Status of Species At Risk in Ontario (COSSARO). He has authored or co-authored more than a dozen COSEWIC status reports. He has been interested in terrestrial gastropods for more than 20 years and has studied and collected them throughout Ontario.

COLLECTIONS EXAMINED

The Global Biodiversity Information Facility, GBIF, database was used to examine several collections worldwide: FLMNH - Florida Museum of Natural History, MCZ - Museum of Comparative Zoology at Harvard University, LI - Biologiezentrum Linz Oberösterreich, NMNH - National Museum of Natural History, Smithsonian Institution, ANSP - Academy of Natural Sciences Philadelphia, NMR - Natural History Museum Rotterdam, FMNH - Field Museum of Natural History, NTSRV - NatureServe Central Databases, MACN - Museo Argentino de Ciencias Naturales (Appendix 3). Collections in Canadian Museums were examined: CMN – Canadian Museum of Nature, ROM – Royal Ontario Museum (Appendix 1) and in Bishops Mills Natural History Centre.

Appendix 1. Records of Proud Globelet (*Patera pennsylvanica*) in Canadian museums and private collections. CMN – Canadian Museum of Nature. CMNML – CMN accession number. ROM – Royal Ontario Museum. ROMCN – ROM accession number. Geographic coordinates have been removed. Contact the COSEWIC Secretariat for access.

Source	Contact	Record	Location	Date	Collector/ Identifier
CMN (CMNML 096171)	Jean-Marc Gagnon	1 adult shell, not alive (fresh dead shells)	Black Oak Woods, west of Ojibway Parkway, south of Broadway, City of Windsor, Essex County	17 July 1992	M.J. Oldham # 14035/ F.W. Grimm
CMN (CMNML 096170)	Jean-Marc Gagnon	5 adult shells, 2 juvenile shells, not alive (fresh dead shells)	Black Oak Woods of Ojibway Prairie, City of Windsor, Essex County	19 April 1996	M.J. Oldham # 18403/ M.J. Oldham
CMN (CMNML 096184)	Jean-Marc Gagnon	5 adult shells, 4 juvenile shells, not alive (old weathered shells)	Black Oak Woods of Ojibway Prairie, City of Windsor, Essex County	27 Aug 2013	A. Nicolai, M. Merkulov # D026a/ A. Nicolai
	Robert Forsyth	1 adult shell, not alive (old weathered shells)	Former light industrial area south of Black Oak Woods of Ojibway Prairie, City of Windsor, Essex County	5 Sep 2013	M.J. Oldham #41549/ R. Forsyth
	Robert Forsyth	5 adult shells, not alive (old weathered shells)	Black Oak Woods of Ojibway Prairie, City of Windsor, Essex County	3 May, 28 July, 2013	A. Nicolai # D025b, # D027c/ A. Nicolai
ROM (ROMCN 19861351)	Maureen Zubowski	5 adult shells, not alive	Indianapolis, Indiana, USA	before 1986	F. Stein
ROM (ROMCN M3771)	Maureen Zubowski	3 adult shells, not alive	Cincinnati, Ohio, USA	before 1974	J.Q. Burch

Appendix 2. Terrestrial gastropods found during the search for Proud Globelet (*Patera pennsylvanica*) in and near the Black Oak Heritage Forest, Windsor, Essex County, in 2013. Observers were Annegret Nicolai (AN), Michael Oldham (MJO), Jane Bowles (JMB) and Mykola Merkulov (MM).* denotes introduced exotic species.

Date	Observer	Method	Conditions	Species	Shells	Alive
May 3	AN, JMB	Transect (GENERAL SURVEY) 1h/person	Afternoon dry, sunny 23°C	*Patera pennsylvanica*	4	
				Neohelix albolabris	4	
				*Cepaea nemoralis**	>1	
July 28	AN	10 m x10 m (ALL COLLECTED) 2h/person	Morning humid, cloudy 20°C	*Patera pennsylvanica*	1	
				Neohelix albolabris	12	
				*Cepaea nemoralis**	1	
				Anguispira alternata	1	
				*Zonitoides nitidus**	2	
				*Arion subfuscus**		3
				*Arion intermedius**		3
				*Arion fasciatus**		1
August 27	AN, MM	Transect (ALL COLLECTED) 2h/person	Noon rainy 23°C	*Patera pennsylvanica*	9	
				Neohelix albolabris	10	
				*Cepaea nemoralis**	6	2
				*Zonitoides nitidus**	3	
				*Arion subfuscus**		12
				*Deroceras reticulatum**	4	
August 27	AN, MM	Transect 1h/person	Midnight rainy 21°C	*Cepaea nemoralis**	>20	
				Ventridens ligera		1
				*Arion subfuscus**	>15	
August 28	AN, MM	Transect including wood dump 2h/person	Early morning humid, cloudy 21°C	*Ventridens ligera*		1
				*Zonitoides nitidus**		>1
September 5	MJO	Transect from wood dump to former light industrial area south of Black Oak Heritage Forest; gastropods restricted to ~ 100 m^2 (GENERAL SURVEY) 3h/person	Early afternoon, sunny, 22°C	*Patera pennsylvanica*	1	
				*Cepaea nemoralis**	>10	>10
				*Xerolenta obvia**	~1000s	~100
				*Arion sp.**		~20

Appendix 3. Museum records of Proud Globelet, *Patera pennsylvanica*, in the Global Biodiversity Information Facility (GBIF) database. FLMNH - Florida Museum of Natural History, MCZ - Museum of Comparative Zoology at Harvard University, LI - Biologiezentrum Linz Oberösterreich, NMNH - National Museum of Natural History, Smithsonian Institution, ANSP - Academy of Natural Sciences Philadelphia, NMR - Natural History Museum Rotterdam, FMNH - Field Museum of Natural History, NTSRV - NatureServe Central Databases, MACN - Museo Argentino de Ciencias Naturales. Geographic coordinates have been removed. Contact the COSEWIC Secretariat for access.

GBIF ID	Institution	Country	State or Province	County	Recorded by	Locality	Date
667849016	FMNH	USA	Illinois	Will	Hand	Brown's Pond	25 Jan 1919
667812023	FMNH	USA	Ohio	Pike	Emberton	Idaho	12 Jun 1982
667899817	FMNH	USA	Illinois	Kendall	Walker	Silver Springs State Park	Aug1988
147567230	FLMNH	USA	Ohio	Hamilton			
667770447	FMNH	USA	Pennsylvania	Allegheny	Teskey	E. end of Sandy Creek	Aug 1948
477074458	MCZ	USA	Michigan			Monroe	
477234838	MCZ	USA	Pennsylvania		Harn	Blairsville	
667848819	FMNH	USA	Indiana	Posey		Grand Chain	
667858098	FMNH	USA	Illinois	Piatt	Zetek	Monticello	1910
667875516	FMNH	USA	Illinois	Washington	Hinkley	Dubois	
667765580	FMNH	USA	Indiana	Martin		Shoals	16 May 1904
667854350	FMNH	USA	Ohio	Hamilton	Over	Valley Junction	23 Apr 1905
147567231	FLMNH	USA	Illinois	La Salle			
667851768	FMNH	USA	Michigan			St. Joseph	Aug 1906
667854639	FMNH	USA	Illinois	La Salle	Billups	Utica	21 Mar 1901
667757460	FMNH	USA	Kentucky	Madison	Hubricht	Richmond	22 Sep 1971
477074347	MCZ	USA	Ohio	Hamilton			
667774824	FMNH	USA	Indiana	Knox		Cypress Swamps	12 Sep 1904
667810926	FMNH	USA	Missouri	Boone	Hubricht	Ashland	18 Sep 1936
667864419	FMNH	USA	Ohio	Franklin		Columbus	
667871698	FMNH	USA	Illinois	St. Clair	Hubricht	Centerville	26 May 1935
667922293	FMNH	USA	Illinois	Vermilion	Richter		
147567914	FLMNH	USA	Illinois	La Salle	Slapcinsky		15 Aug 1998
215799979	ANSP	USA	Illinois	Washington		Dubois	
215801074	ANSP	USA	Pennsylvania	Beaver		Connelton	
786916630	FLMNH	USA	Ohio	Hamilton			1967
215800815	ANSP	USA	Ohio				
147567925	FLMNH	USA	Illinois	Cook	Slapcinsky		1 May 1997
477092461	MCZ	USA	Ohio			Miami Bottoms	
477118141	MCZ	USA	Kentucky		Byrnes	West Covington	1874
667802706	FMNH	USA	Missouri	Boone	Hubricht	Providence	5 Sep 1936
667792499	FMNH	USA	Ohio	Hocking	Emberton	Creek Road	2 Jun 1979
667815572	FMNH	USA	Indiana			Indianapolis	

GBIF ID	Institution	Country	State or Province	County	Recorded by	Locality	Date
667865858	FMNH	USA	Indiana	Franklin		Brookville	2 May 1903
667799772	FMNH	USA	Indiana	Franklin		Brookville	15 May1902
147567235	FLMNH	USA	Ohio				
147568456	FLMNH	USA	Illinois	Washington	Hinkley		1915
667759973	FMNH	USA	Ohio	Hamilton	Baker		
147567234	FLMNH	USA	Ohio	Pickaway			
477169908	MCZ	USA	Ohio		Lea	Cincinnati	
667761581	FMNH	USA	Indiana		Teskey	Anderson	24 Jul 1951
667797023	FMNH	USA	Illinois	Hancock		Hamilton	
667852067	FMNH	USA	Illinois		Hand	Joliet	
667854641	FMNH	USA	Indiana		Billups	Lawrenceburg	1900
147567225	FLMNH	USA	Illinois	Washington	Hinkley		
667787221	FMNH	USA	Illinois	Woodford	Foster	Goodfield	31 Aug 1931
667854211	FMNH	USA	Illinois			Morris	2 Jul 1908
667854640	FMNH	USA	Ohio	Hamilton			15 Avr 1902
667884241	FMNH	USA	Indiana			Indianapolis	
215800963	ANSP	USA	Ohio	Greene		Yellow Springs	
667883919	FMNH	USA	Pennsylvania	Philadelphia	Post	Philadelphia	
667854357	FMNH	USA	Ohio	Hamilton			1900
215800964	ANSP	USA	Ohio				
477107316	MCZ	USA	Illinois		Jacobson	Utica	
667816109	FMNH	USA	Ohio			Cincinnati	
667858316	FMNH	USA	Pennsylvania	Alle		Edgeworth	
667860164	FMNH	USA	Ohio	Hamilton		Cincinnati	
667868744	FMNH	USA	Illinois	Mason	Hubricht	Havana	03 Oct 1942
147567738	FLMNH	USA	Indiana	Marion			
477118251	MCZ	USA	Illinois			Hamburg	01 Aug 1882
215801084	ANSP	USA	Pennsylvania	Greene		Crucible	
667854647	FMNH	USA	Indiana		Billups	Lawrenceburg	1900
477092460	MCZ	USA	Ohio		Bennett	Circleville	
667793039	FMNH	USA	Indiana			Indianapolis	
476897131	MCZ	USA	Ohio			Miami Bottoms	
13074533	LI	USA	Missouri		Kemper	Fertile	03 May 1971
667782028	FMNH	USA	Illinois	Hancock	Caruthers	Hamilton	
667858099	FMNH	USA	Ohio	Summit		Hudson	
667873768	FMNH	USA	Ohio	Pike	Van Devender	Waverley Dump	18 Aug 1982
215800816	ANSP	USA	Ohio	Hamilton		Cincinnati	
667768294	FMNH	USA	Indiana	Marion		Cumberland	
667825120	FMNH	USA					
667851091	FMNH	USA	Illinois		Hand	Chicago	27 Nov 1907
667880356	FMNH	USA	Missouri	Washington	Schilling	Fertile	06 Avr 1978

GBIF ID	Institution	Country	State or Province	County	Recorded by	Locality	Date
477092462	MCZ	USA	Indiana	Marion	Hinkley		
856769177	NMR	USA	Ohio			Cincinnati	06 Jul 1978
856685353	NMR	USA	Pennsylvania			Butler Junction	
667764110	FMNH	USA	Ohio	Pike	Van Devender	City Dump, Waverly	Jul 1983
667815425	FMNH	USA	Ohio	Hamilton			
667900235	FMNH	USA	Missouri	St. Louis	Hubricht	Fern Glen	27 May 1933
667854355	FMNH	USA	Indiana		Billups	Lawrenceburg	23 Avr 1903
215801611	ANSP	USA	West Virginia	Ohio		Wheeling	
147567226	FLMNH	USA	Ohio				
13074529	LI	USA		Marion	Snyder	Indiana	
667854210	FMNH	USA	Indiana		Daniels	Brookville	02 May 1903
667854375	FMNH	USA	Indiana		Billups	Lawrenceburg	18 May 1902
215801400	ANSP	USA	Ohio	Licking		Newark	
476900117	MCZ	USA	Ohio			Cincinnatti	
667756585	FMNH	USA	Kentucky	Kenton		West Covington	
667790965	FMNH	USA	Missouri	St. Charles	Hubricht	Harvester	01 Dec 1935
667848820	FMNH	USA	Indiana			Indianapolis	
667854364	FMNH	USA	Ohio		Wetherby	Cincinnati	10 Nov 1902
667864264	FMNH	USA	Indiana	Marion		Indianapolis	
477067817	MCZ	USA	Pennsylvania		Burnett	Bradford	1929
215801069	ANSP	USA	Pennsylvania	Allegheny		Quinwood	
215801201	ANSP	USA	Ohio	Adams		Serpent Mound	
215801079	ANSP	USA	Pennsylvania	Washington		New Eagle	
147567232	FLMNH	USA	Ohio	Hamilton			
147567892	FLMNH	USA	Iowa	DesMoines	Slapcinsky& Nekola		12 Jul 1998
667747365	FMNH	USA	Missouri	Washington	Schilling	Fertile	18 May 1976
667854351	FMNH	USA	Ohio	Hamilton	Collins	Harrison	23 Avr 1905
477063320	MCZ	USA	Indiana			Indianapolis	08 Oct 2001
667854646	FMNH	USA	Ohio			Miami Grove	1900
667809277	FMNH	USA	Illinois	Calhoun	Hubricht	Hardin	17 Sep 1933
667799875	FMNH	USA	Missouri		Schilling	Washington State Park	19 May 1971
667860166	FMNH	USA	Indiana	Marion		Indianapolis	
667864423	FMNH	USA	Ohio	Hamilton		Cincinnati	
231042895	MACN	USA	Pennsylvania			Pittsburgh	
147567734	FLMNH	USA	Pennsylvania	Mckean Co.			
215801081	ANSP	USA	Kentucky	Bath		Owingsville	
147567228	FLMNH	USA	Ohio				
147568449	FLMNH	USA	Indiana	Gibson Co.	Tucker		06 Jun 1976
667755347	FMNH	USA	Iowa	Van Buren	Crabb	Keosauqua State Park	15 Jul1941
667844942	FMNH	USA	Ohio			Cincinnati	
477009445	MCZ	USA	Ohio		Bennett	Circleville	

GBIF ID	Institution	Country	State or Province	County	Recorded by	Locality	Date
147567912	FLMNH	USA	Illinois	La Salle	Slapcinsky		03 Dec 1988
215801072	ANSP	USA	Pennsylvania	Allegheny		Quinwood	
215801068	ANSP	USA	West Virginia			Smithville	
215801200	ANSP	USA	Ohio	Adams		Peebles	
667778572	FMNH	USA	Missouri	St. Louis	Hubricht	Hine	06 Aug 1933
667840738	FMNH	USA	Ohio				
147567233	FLMNH	USA	Kentucky				
147567398	FLMNH	USA	Iowa	Polk Co.	Van Hyning		
667751518	FMNH	USA	Missouri	Washington	Schilling	Fertile	15 May 1975
667754494	FMNH	USA	Illinois		Johnson	Joliet	
667768750	FMNH	USA	Missouri	St. Louis	Hubricht	Cliff Cave	01 Jun 1933
667800991	FMNH	USA	Pennsylvania	Bradford	Hubricht	Wysox	30 Jul 1974
667854352	FMNH	USA	Ohio	Hamilton	Wetherby		12 Jan 1902
137558758	USNM	USA	Virginia		Rowley	Front Royal Cons. Center	Jun 1985
476896636	MCZ	USA	Illinois			Canton	
667762322	FMNH	USA	Missouri	Washington	Hubricht	Washington State Park	04 Jul 1937
667841423	FMNH	USA	Pennsylvania			Bradford	
667876898	FMNH	USA	Ohio	Hamilton	University	Cincinnati	Dec 1963
215800965	ANSP	USA	Ohio				
215801070	ANSP	USA	Pennsylvania	Allegheny		Quinwood	
215809908	ANSP	USA	Pennsylvania	Westmoreland		Ligonier	
667841367	FMNH	USA	Ohio			Cincinnati	
667894464	FMNH	USA	Ohio	Greene	Hubricht	Oldtown	19 Jul 1958
147567227	FLMNH	USA	Pennsylvania				
147568448	FLMNH	USA	Indiana	Gibson Co.	Tucker		06 Jun 1976
215801080	ANSP	USA	Pennsylvania	Fayette		Indian Creek	
667936846	FMNH	USA	Illinois	Fulton	Gerber	Anderson Lake	04 Sep 2006
215801071	ANSP	USA	West Virginia	Ohio		Wheeling	
667747219	FMNH	USA	Illinois	Monroe	Hubricht	Valmeyer	09 Sep 1934
667841368	FMNH	USA	Ohio	Summit			
667844437	FMNH	USA	Indiana			Indianapolis	
667891792	FMNH	USA	Illinois	Madison	Hubricht	Collinsville	06 Jul 1934
147567229	FLMNH	USA	Ohio				
215799978	ANSP	USA	Pennsylvania	Greene		Waynesburg	
215801073	ANSP	USA	Pennsylvania	Allegheny		Quinwood	
147567913	FLMNH	USA	Illinois	La Salle	Slapcinsky		15 Aug 1998
667875954	FMNH	USA	Ohio			Cincinnati	
614458491	NMR	USA	Ohio			Cincinnati	
667849015	FMNH	USA	Illinois	Will		Joliet	26 Jul 1917
147567736	FLMNH	USA	Indiana	Marion Co.	Marsh		
614458457	NMR	USA	Pennsylvania			Butler Junction	
667858095	FMNH	USA	Illinois	Washington	Hinkley & Zetek	DuBois	08 Jul 1909

GBIF ID	Institution	Country	State or Province	County	Recorded by	Locality	Date
36508269	NTSRV	Canada	Ontario	Essex		Windsor	1996
477074457	MCZ	USA	Ohio			Avondale	
667847012	FMNH	USA	Illinois		Strandine	Joliet	06 Jun 1937
667858100	FMNH	USA	Kansas	Bourbon	Becker	Fort Scott	
667878263	FMNH	USA	Illinois	Madison	Hubricht	Alton	18 Oct 1936
231042733	MACN	USA	Indiana			Indianapolis	
667858096	FMNH	USA	Illinois	Champaign	Glasgow	Urbana	10 Avr 1908